Folsom dam site on American River
Looking upstream

STATE OF CALIFORNIA
DEPARTMENT OF PUBLIC WORKS

REPORTS OF THE
DIVISION OF WATER RESOURCES
EDWARD HYATT, State Engineer

BULLETIN No. 24

A PROPOSED MAJOR DEVELOPMENT

ON

AMERICAN RIVER

An Analysis of Its Utility in the Coordinated
Plan for the Development of the
Water Resources of California

By
A. D. EDMONSTON, Deputy State Engineer

A Report to Joint Legislative Committee of 1927 on Water
Resources and to the State Department of Finance

1929

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LETTER OF TRANSMITTAL

Honorable B. S. Crittenden, *Chairman*
Joint Legislative Committee on Water Resources.

Mr. A. R. Heron, *Director of Finance.*

Sirs: In accordance with your requests there has been prepared and is transmitted herewith a report on a proposed development on the American River. This report analyzes the contemplated hydroelectric project of the American River Hydro-electric Company on the lower American River. The power possibilities of the project are studied under two methods of water release primarily for power generation, and the service obtainable from the development in flood control, salinity control and irrigation, has been calculated and is included. Surveys and certain other data furnished by the American River Hydro-electric Company have been used in the preparation of the report.

Very truly yours,

State Engineer.

Sacramento, California.

ENGINEERING ADVISORY COMMITTEE

This bulletin has been prepared in consultation with an engineering advisory committee. The members of the committee are:

Paul Bailey	Louis C. Hill
A. J. Cleary	Walter L. Huber
G. A. Elliott	A. Kempkey
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This report has been prepared by

A. D. EDMONSTON - - - - - *Deputy State Engineer*

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CHAPTER I

INTRODUCTION

The American River Hydro-electric Company contemplates a major hydro-electric development on the American River which would include construction of storage dams and reservoirs of large capacity, together with power plants below the dams. One of the major reservoirs, Folsom, is a unit in the "Coordinated Plan"* for the development of the waters of the State. The other two reservoirs, Auburn and Coloma, are located on the lower reaches of the North and South Forks, respectively, above the Folsom reservoir and are important elements in the ultimate comprehensive plan † of the development of the State's waters. The geographic relation of the proposed development to the units of the "Coordinated Plan" is indicated on Plate I, "Coordinated Plan for the development of water resources of California, as reported to the Legislature of 1927." On this map only the Folsom reservoir of the proposed development is shown. The others would be directly upstream from it. Because of the importance of the American River in the state-wide plan for the development of its water resources, the Joint Legislative Committee on Water Resources and the Department of Finance requested that a study and a report be made of the utility of the proposed development in the state-wide plan.

In connection with the investigation, assistance has been received from the American River Hydro-electric Company, State Reclamation Board and American River Flood Control District. The American River Hydro-electric Company furnished topographic maps of the several reservoirs and dam sites, a geological report on the dam sites, data on subsurface explorations at the site of the proposed Folsom dam and a proposed method of operating the reservoirs primarily for power. The State Reclamation Board and the American River Flood Control District, in the early stages of the investigation, furnished engineering assistance in certain phases of the study.

In 1924, a general study of the American River, comparing various schemes of utilization of water resources of the basin, was made and a report§ rendered thereon by a board of engineers appointed by the Federal Power Commission and composed of representatives of the Federal Government and a representative of the State of California. The purpose of the investigation was "to make a general study of the American River in California with a view to comparing various schemes of utilization of water resources, and outlining such schemes as are best suited to the needs of power, irrigation, and domestic supply, bearing in mind the effect produced on interests dependent on the lower Sacramento River, notably navigation and island irrigation."

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* See Bulletin No. 12, "Summary Report on the Water Resources of California and a Coordinated Plan for their Development," Division of Engineering and Irrigation, State Department of Public Works.

† See Chapter VI, Bulletin No. 4, "Water Resources of California," Division of Engineering and Irrigation, State Department of Public Works.

§ Report to the Federal Power Commission on the uses of the American River, California.

Among the conclusions of its report, the board states:

"b. That storage facilities in the American River Basin should be dedicated to irrigation and power primarily, since their economic value for these purposes is too great to justify their development solely for flood control."

"d. That until investigations show that large storage for valley irrigation can not be feasibly developed on the lower reaches of the North and Middle Forks below river elevation 1150 it is inadvisable to permit power development which would interfere with irrigation storage below this elevation."

"e. That the Coloma† Reservoir has sufficient capacity and is so located that it can regulate for the benefit of irrigation almost the entire flow of the South Fork of the American River below power developments. Its primary value is for irrigation storage."

"f. That the Folsom Dam§ site admits raising the dam to a considerable additional height, and that this site is located at the logical point for diverting American River water for all lower gravity irrigation."

It, therefore, would appear that it was the opinion of this board that storage works on the American River should be dedicated primarily to irrigation and power and, on the lower reaches of the stream, particularly below elevation 1150 feet on the North and Middle Forks, to irrigation. The value of the Coloma reservoir on the South Fork was to be considered primarily as irrigation storage and the Folsom dam site was the logical point for the diversion of irrigation water for lands adjacent to the American River.

The Auburn reservoir located on the North Fork lies below elevation 1150 feet and the Coloma and Folsom reservoirs analyzed in this report occupy generally the same position as the ones mentioned under the same name in the Federal Power Commission report.

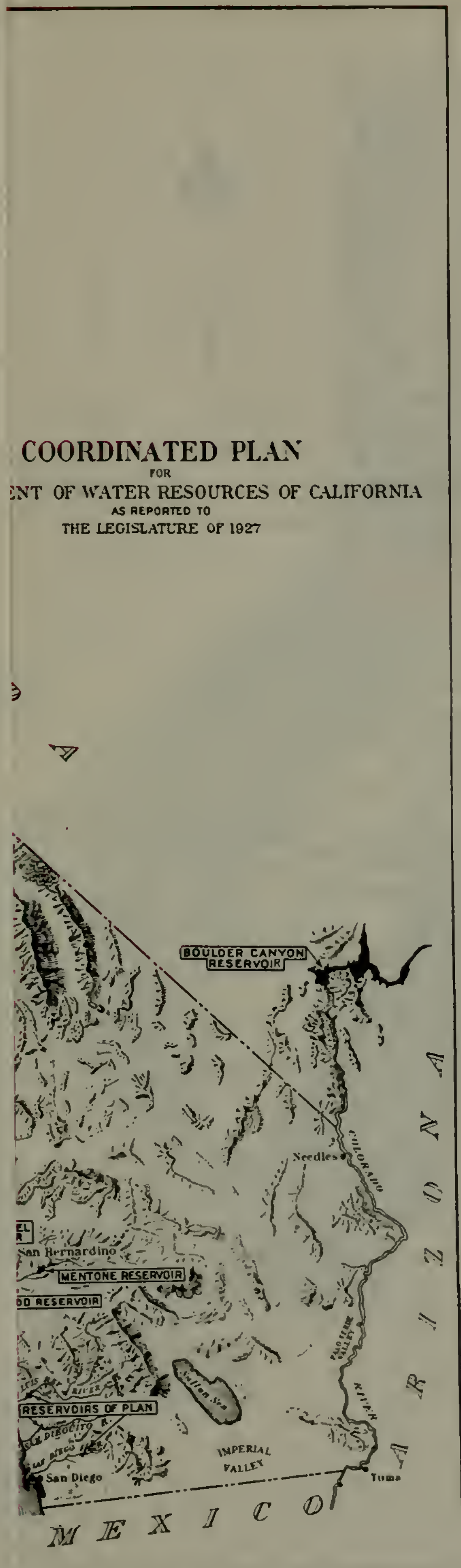
This investigation does not deal with the development of the entire watershed but only with a specific project proposed by the American River Hydro-electric Company. It analyzes the service obtainable from this development in flood control, salinity control, irrigation and power. Engineering, economic and financial phases have been considered in relation to the power development. The economic sizes of reservoirs, however, at the several sites have not been investigated. The sizes of reservoirs as proposed by the American River Hydro-electric Company have been used as a basis for the analyses. The probability of improving the financial aspects of the development by enlarging the existing power plant at Folsom city which might be justified by the creation of upstream storage has not been investigated. The surveys of the American River Hydro-electric Company have been accepted as being correct and are a basis for the estimates appearing in this report. Only one dam site, Folsom, has been drilled. The other sites have been examined by a geologist and a favorable report rendered thereon for the heights of dam considered in the proposal.

The project herein discussed is not presented as the most economic development on the lower American River, nor as the one that would be most desirable for inclusion in the state-wide plan. Rather, it is analyzed as a specific project to determine its utility in the state plan. Further studies might indicate changes in reservoir capacities and power plant installations to be economically justified, which changes would be reflected in the yield and cost estimates.

† Reference is to upper Coloma dam site mentioned in this report.

§ Reference is to existing Folsom Prison dam.

PLATE I


COORDINATED PLAN
FOR
NT OF WATER RESOURCES OF CALIFORNIA
AS REPORTED TO
THE LEGISLATURE OF 1927
BOULDER CANYON RESERVOIR
Needles
COLORADO
San Bernardino
MENTONE RESERVOIR
RESERVOIRS OF PLAN
San Diego
IMPERIAL VALLEY
Yuma
ARIZONA
MEXICO

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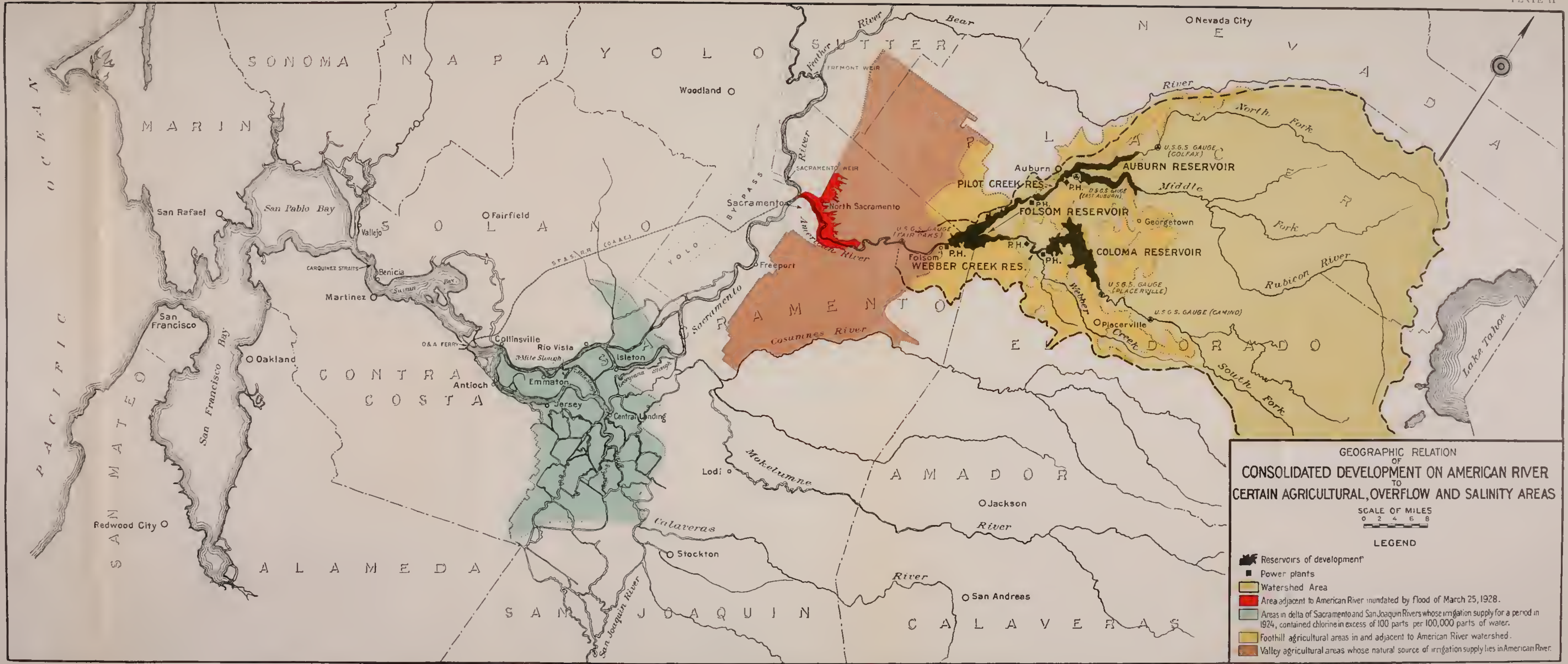
† Reference is to upper Coloma dam site mentioned in this report.
§ Reference is to existing Folsom Prison dam.


COORDINATED PLAN
FOR
DEVELOPMENT OF WATER RESOURCES OF CALIFORNIA
AS REPORTED TO
THE LEGISLATURE OF 1927
OREGON
NEVADA
ARIZONA
MEXICO
PACIFIC OCEAN
COAST RANGE
SIERRA NEVADA MOUNTAINS
FAIRVIEW RESERVOIR
KENNETT RESERVOIR
TRINITY RIVER DIVERSION
OROVILLE RESERVOIR
NARROWS RESERVOIR
PARKER RESERVOIR
FOLSOM RESERVOIR
TEMPERANCE FLAT RESERVOIR
PINE FLAT RESERVOIR
FRIANT-KINGS RIVER CANAL
KINGS RIVER-EARLIMART CANAL
BAKERSFIELD RESERVOIR
ISABELLA RESERVOIR
BOULDER CANYON RESERVOIR
SAN GABRIEL RESERVOIR
RESERVOIRS OF PLAN
MENTONE RESERVOIR
PRADO RESERVOIR
RESERVOIRS OF PLAN
DAM 1
DAM 2
DAM 3
DAM 4
DAM 5
DAM 6
DAM 7
DAM 8
DAM 9
DAM 10
DAM 11
DAM 12
DAM 13
DAM 14
Mt Shasta
Eureka
Redding
Mt Lassen
Red Bluff
Head of Navigation
Chico
Lake Tahoe
Sacramento
Suisun Bay
Mt Diablo
San Francisco
Stockton
Modesto
Merced
Fresno
Mono
Bishop
Mt Whitney
Owens Lake
Visalia
Bakersfield
Santa Barbara
Los Angeles
San Bernardino
Santa Ana
Needles
San Diego
Yuma
IMPERIAL VALLEY
SACRAMENTO RIVER
FEATHER RIVER
YUBA
BEAR
AMERICAN
MOKELUMNE RIVER
CALAVERAS
STANISLAUS
TUOLUMNE
MERCED
FRESNO RIVER
KINGS
KAWEAH
KERN
COLORADO RIVER


GEOGRAPHIC RELATION
OF
CONSOLIDATED DEVELOPMENT ON AMERICAN RIVER
TO
CERTAIN AGRICULTURAL, OVERFLOW AND SALINITY AREAS
SCALE OF MILES
0 2 4 6 8
LEGEND
Reservoirs of development
Power plants
Watershed Area
Area adjacent to American River inundated by flood of March 25, 1928.
Areas in delta of Sacramento and San Joaquin Rivers whose irrigation supply for a period in 1924, contained chlorine in excess of 100 parts per 100,000 parts of water.
Foothill agricultural areas in and adjacent to American River watershed.
Valley agricultural areas whose natural source of irrigation supply lies in American River.
PACIFIC OCEAN
SONOMA
NAPA
YOLO
SUTTER
NEVADA
PLACER
MARIN
SOLANO
SACRAMENTO
EL DORADO
CONTRA COSTA
SAN MATEO
ALAMEDA
SAN JOAQUIN
AMADOR
CALAVERAS
Nevada City
Woodland
Auburn
AUBURN RESERVOIR
PILOT CREEK RES.
FOLSOM RESERVOIR
COLOMA RESERVOIR
WEBBER CREEK RES.
P.H.
Georgetown
Placerville
Folsom
Sacramento
North Sacramento
Freeport
Fairfield
San Rafael
San Pablo Bay
Vallejo
Benicia
CARQUINEZ STRAITS
Martinez
Suisun Bay
San Francisco
Oakland
San Francisco Bay
Redwood City
Collinsville
Rio Vista
Isleton
Emmaton
Antioch
Jersey
Central Landing
O&A FERRY
3 Mile Slough
Georgiana Slough
Lodi
Stockton
Jackson
San Andreas
Lake Tahoe
U.S.G.S. GAUGE (GOLFAX)
U.S.G.S. GAUGE (EAST AUBURN)
U.S.G.S. GAUGE (FAIR OAKS)
U.S.G.S. GAUGE (PLACERVILLE)
U.S.G.S. GAUGE (CAMINO)
SACRAMENTO WEIR
FREMONT WEIR
YOLO BYPASS
S.F.&S.RR. (O.A.&C.)
Feather River
Bear River
Sacramento River
American River
North Fork
Middle Fork
South Fork
Rubicon River
Webber Creek
Cosumnes River
Mokelumne River
Calaveras River
San Joaquin River

SUMMARY

General.

In the analysis of the consolidated development, consideration has been given to three progressive stages of development operated for various uses and combination of uses; that is power, flood control, salinity control and irrigation. The operation of the reservoirs primarily for power generation has been studied for two methods of water release. Capital and annual costs have been estimated for both state and private financing and the annual costs under private financing have been estimated both with and without state taxes. The power installation at each reservoir has been based on two plant load factors.

The report, therefore, contains many tables under the many analyses, and on account of their volume, only a summary of the results of the studies is presented in this chapter. Details supplementing this summary will be found in the succeeding chapters.

Drainage basin and water supply.

The American River, the second largest tributary of the Sacramento River below Red Bluff, drains an area of 1919 square miles. The average yield in seasonal run-off was 2,953,000 acre-feet for the period 1904–27, which varied from a minimum of 551,000 acre-feet in 1923–24 (18.7 per cent of the average), to a maximum of 5,783,000 acre-feet in 1906–07 (196 per cent of the average). The average monthly distribution varied from 0.5 per cent in September to 19.8 per cent in May, of average seasonal run-off for the period 1904–27.

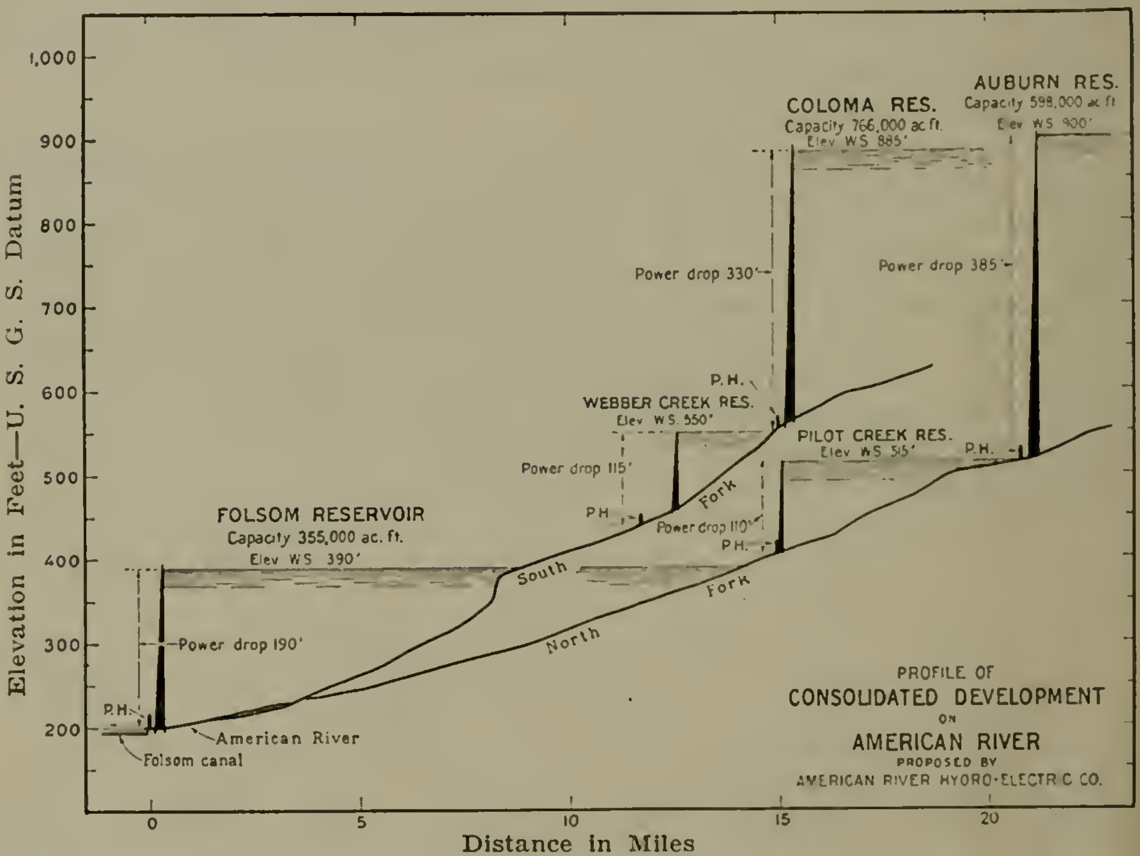
The drainage areas and seasonal run-offs above the three major reservoirs are as follows:

Reservoir	Location	Drainage area		Average seasonal run-off 1904-1927	
		Square miles	Per cent of total above Fairoaks gaging station	Acre-feet	Per cent of total above Fairoaks gaging station
Folsom	Main stream	1,875	97.7	2,948,000	99.8
Auburn	North Fork	965	50.3	1,718,000	58.2
Coloma	South Fork	708	36.9	1,063,000	36.0

Consolidated development.

The plans of the American River Hydro-electric Company call for the construction of three major reservoirs, Folsom, Auburn and Coloma, and two minor reservoirs, Pilot Creek and Webber Creek, together with a power plant below each of the five dams. The plan of the development is delineated on Plate II, "Geographic relation of consolidated development on American River to certain agricultural, overflow and salinity areas." The total storage capacity of the major reservoirs would be ,719,000 acre-feet. The capacity of the minor reservoirs is relatively mall. A power drop could be developed between the water level elevation of 900 feet and 885 feet of the Auburn and Coloma reservoirs, espectively, and the tailrace elevation of 162 feet of the lowest power lant. The maximum water surface elevation of the Folsom reservoir vould be 390 feet. The power drop obtainable by the development is shown on Plate III, "Profile of consolidated development on American River proposed by American River Hydro-electric Company." The total power installation as proposed by the company would be 200,000 kilovolt amperes and is based on a power factor of 80 per cent and operation at a maximum monthly plant load factor of 60 per cent for all plants except Folsom which would be installed on a plant load factor of 100 per cent. Plant load factor as used herein is the ratio of the average power output in kilowatts to the rated capacity of the plant in kilowatts. An alternative installation based on a plant load factor of 75 per cent for all plants is proposed in this report, which would allow a comparison of costs of the units of the "Coordinated

PLATE III



Plan." With this plant load factor and 80 per cent power factor the total power installation would be 179,000 kilovolt amperes.

In the following table of data on the various units, the figure for the power installation of the Folsom plant for each proposal is for the ultimate development or in conjunction with Auburn reservoir. With Folsom alone, the installed capacity would be 35,000 k.v.a. under the first proposal and 43,000 k.v.a. under the second. The plant layout at the Folsom plant as proposed by the American River Hydro-electric Company would release part of the water from the turbines into the existing Folsom Canal and part into the American River below the existing Folsom Prison dam, at tailrace elevations of 207 and 162 feet, resulting in maximum power heads of 183 and 228 feet, respectively.

The layout for the Folsom plant as proposed in this report would release all the water from the turbines into the Folsom Canal, deepened 7 feet for a distance of about 1600 feet, at tailrace elevation 200 feet, which would give a maximum power head of 190 feet. As the capacity of the Pilot Creek and Webber Creek reservoir is relatively small, no consideration in the studies has been given to any possible usable storage.

Reservoir	Height of dam, in feet	Capacity of reservoir, in acre-feet	Maximum power head, in feet	Installed capacity of power plant, in k.v.a. P.F.=0.80	
				Load factor =0.75	Load factor =0.60
Folsom	190	355,000	183-228	54,000	*45,000
Auburn	390	598,000	385	66,000	82,000
Pilot Creek	110	....	110	19,000	23,000
Coloma	340	766,000	330	30,000	37,000
Webber Creek	90	....	115	10,000	13,000
Total	....	1,719,000	....	179,000	200,000

*Load factor =1.00.

Power output.

In estimating the power output of the development operated primarily for power generation, two methods of water release from the reservoirs have been analyzed. One method of release would develop maximum continuous or primary power throughout the year in conformity with the state-wide demand for power, including extremely dry seasons such as 1923–24, by varying the water release with the head on the plant, and also additional intermittent seasonal or secondary power up to the capacity of the economic power installation when water would be available in excess of that required for the generation of the primary power. This method has been employed in estimating the power yield of the various units of the "Coordinated Plan," when operated primarily for power purposes and is included herein to allow a comparison with those units. The second method, proposed by the American River Hydro-electric Company would release water through the turbines at a more or less constant rate, developing a larger amount of power but somewhat more variable than in the first instance. In this method, the reservoirs would be drawn to low levels at the end of each season and the amount of power generated would have a greater variation from season to season and from month to month in the season than with the first method.

The average total power output of the development for the period 1905–1927, operated primarily for power generation would have been 689,500,000 kilowatt hours per year, with a schedule of water release from the reservoir to develop maximum primary power and for a layout at the Folsom plant with a tailrace elevation of 200 feet. It would have been 773,100,000 kilowatt hours per year with a schedule of water release proposed by the American River Hydro-electric Company and for a plant layout at Folsom with tailrace elevations of 162 and 207 feet. The average annual power outputs of the several plants are:

Power plant	Average annual power output, 1905-1927, in kilowatt hours	
	With schedule of water release to develop maximum primary power	With schedule of water release in accord with schedule proposed by American River Hydro-electric Company
Folsom	*217,400,000	†262,700,000
Auburn	221,900,000	245,800,000
Pilot Creek	63,900,000	80,500,000
Coloma	136,700,000	133,700,000
Webber Creek	49,600,000	50,400,000
Total	689,500,000	773,100,000

*Power output with Auburn and Coloma reservoirs constructed. Power output with Folsom reservoir only constructed, 153,700,000 kilowatt hours per year; with Auburn reservoir constructed, 195,300,000 kilowatt hours per year.
†Power output with Auburn and Coloma reservoirs constructed. Power output with Folsom reservoir only constructed, 160,200,000 kilowatt hours per year; with Auburn reservoir constructed, 242,900,000 kilowatt hours per year.

The characteristics of the power output, 1905–1927, for the complete development operated primarily for power generation with the two methods of water release are shown in the following table:

Month	State-wide average monthly demand for power in per cent of annual total	Power output, 1905-1927					
		With schedule of water release to develop maximum primary power			With schedule of water release proposed by American River Hydro-electric Company		
		Maximum year, 1907, in per cent of annual total	Minimum year, 1924		Maximum year, 1909, in per cent of annual total	Minimum year, 1924	
			In per cent of annual total	In per cent of annual total of maximum year		In per cent of annual total	In per cent of annual total of maximum year
January	7.3	9.0	7.2	4.7	7.7	13.0	5.2
February	6.9	8.1	6.8	4.5	7.9	14.4	5.8
March	7.8	9.0	7.7	5.1	8.8	12.0	4.8
April	7.9	8.7	7.8	5.1	8.4	13.7	5.5
May	8.8	9.0	8.7	5.7	8.8	12.5	5.0
June	9.0	8.7	8.8	5.8	8.4	8.7	3.5
July	9.4	9.0	9.3	6.1	8.7	8.7	3.5
August	9.5	9.0	9.5	6.2	8.6	2.5	1.0
September	8.7	7.3	8.7	5.7	8.1	0.8	0.3
October	8.5	6.7	8.7	5.7	8.2	1.8	0.7
November	8.0	6.8	8.2	5.4	7.9	4.7	1.9
December	8.2	8.7	8.6	5.6	8.5	7.2	2.9
Total	100.0	100.0	100.0	65.6	100.0	100.0	40.1

Irrigation service.

It was found, in formulating the comprehensive plan of water development of the State, that storage works on the streams of the State must be provided to equalize the large volumes of run-off from the mountain watersheds occurring during the flood season, for the irrigation of the agricultural lands lying at lower elevations. The most favorable position for these storage works is at elevations intermediate between the agricultural and mountain areas where mining and power uses predominate. The reservoirs of the consolidated development are in this position on the American River and are capable of being developed to large capacity, which could be utilized for the purpose of equalizing the irregular flow of the American River for irrigation purposes.

The comprehensive plan of water development for the Sacramento and San Joaquin valleys comprehends the storage of flood waters in the Sacramento River drainage basin for fully supplying the demands of the agricultural lands of the Sacramento Valley and also, releasing the water surplus to needs of the Sacramento Valley, to areas of deficient water supply in the San Joaquin Valley. The American River with other streams has a surplus to the local irrigation needs, which could be transported to the San Joaquin Valley.

The yield of the reservoirs in seasonal irrigation draft, without deduction for downstream prior rights, and the area capable of being served for each stage of progressive development is given in the following table for the period 1905–27, with the reservoirs operated primarily for irrigation purposes and also with the two methods of water release primarily for power generation. The seasonal irrigation drafts are estimated on the basis of a total deficiency in the irrigation supply of 50 per cent of a perfect seasonal supply for the entire period, 1905–27. The total deficiency would have occurred in one year or would have been divided among several. The area of service is estimated on a seasonal duty of water of 2.5 acre-feet per acre, which includes full use of return waters. In the estimates for the reservoirs operated primarily for irrigation, the operation of the existing Folsom City power plant is subordinated to the operation of the reservoirs for irrigation.

Stage of development	Reservoirs operated primarily for irrigation		Reservoirs operated primarily for power generation			
			With method of water release to develop maximum primary power		With method of water release proposed by American River Hydro-electric Company	
	Seasonal irrigation draft, without deduction for downstream prior rights and with an average seasonal deficiency in supply, 2.2 per cent of perfect seasonal supply, in acre-feet	Area of service, in acres	Seasonal irrigation draft, without deduction for downstream prior rights and with an average seasonal deficiency in supply, 2.0 per cent of perfect seasonal supply, in acre-feet	Area of service, in acres	Seasonal irrigation draft, without deduction for downstream prior rights and with an average seasonal deficiency in supply, 2.0 per cent of perfect seasonal supply, in acre-feet	Area of service, in acres
Initial development— Folsom reservoir alone	664,000	266,000	297,000	119,000	49,600	20,000
Second stage of development— Folsom and Auburn reservoirs	1,250,000	500,000	430,000	172,000	96,000	38,000
Complete development— Folsom, Auburn and Coloma reservoirs	1,757,000	703,000	578,000	231,000	729,000	292,000

Valley agricultural lands susceptible of irrigation from American River.

North and south of the American River and east of the Sacramento and Feather rivers there is a gross area of valley floor and plains lands whose natural and economic irrigation supply lies in the American River. The total irrigation requirements for full development of these lands are estimated at 650,000 acre-feet per season.

Of the total area, on the north side of the American River, 200,000 acres, 65 per cent could be irrigated with the supply diverted at the tail water of the Folsom plant, elevation 200 feet. The remainder, 35 per cent, would require a diversion above the Folsom reservoir, probably at the Pilot Creek dam. To irrigate a total gross area of 150,000 acres lying between the Cosumnes and American rivers would require a diversion at the tailrace of the Folsom plant, elevation 200 feet. If the plans of the American River Hydro-electric Company were consummated, and water discharged into the stream at elevation 162 feet below the Folsom Prison dam, the area on the south side of the American River, capable of being served, would be reduced by 30 per cent.

Flood control.

The need for flood control on the American River has long been recognized by the state and national governments. The United States Congress in 1917 and the State Legislature in 1911 adopted a general plan of flood control for Sacramento Valley, which included a provision for flood control on the lower American River. In 1927, the State Legislature created the American River Flood Control District comprising the cities of Sacramento and North Sacramento, and contiguous unincorporated territory in Sacramento County.

Several plans for the protection of this area from floods have been proposed, which can be divided into two general systems of control, with and without supplementary control by upstream reservoirs. Both systems would require leveed channels along the river. With supplementary reservoir control, the width of the channel could be reduced about one-half, thereby reclaiming a larger area and minimizing the cost of crossings.

The largest flood during the 24-year period of stream flow measurement at the Fairoaks gaging station of the United States Geological Survey, occurred on March 25, 1928. It was the largest flood on which there is authentic record. The crest discharge was 184,000 second-feet. The mean for the day was 120,000 second-feet and for the maximum 24-hour period, 10 a.m. on March 25 to 10 a.m. on March 26, 148,000 second-feet. The second largest flood occurred on March 19, 1907, when the crest discharge was 119,000 second-feet and the mean for the day was 105,000 second-feet.

An analysis of the flood flows for the period of stream measurement at the Fairoaks gaging station indicates that still larger floods than those measured may be expected to occur in the future. The size of flood flows that may occur at various average intervals of time has been estimated from an analysis of the floods which have occurred during the period of stream measurement, in a manner similar to that set forth in Bulletin No. 14, "The Control of Floods by Reservoirs" of the Division of Engineering and Irrigation. The only assumption made in the analysis is that whatever relation exists between size and frequency of occurrence of floods is contained in the period of stream measurement. The following table sets forth the size of flood expressed in second-feet, inches depth on the drainage area and second-feet per square mile of drainage area, that may be expected to be exceeded on specified average number of days in 100 years. The values given in the table are mean daily flows. Values of crest discharge of any particular flood would be considerably larger than the figures set forth in the table. It may be noted that a maximum mean daily flow of 56,000 second-feet may be expected to be exceeded on the average of 100 days in 100 years or one day each year, and a maximum mean daily flow of 162,000 second-feet may be expected to be exceeded one day in 100 years.

Average number of days in 100 years on which maximum mean daily flows may be expected to be exceeded	Maximum mean daily flow at Fairoaks gaging station		
	In second-feet	Inches depth in 24 hours on drainage area, (1919 square miles)	Second-feet per square mile of drainage area, (1919 square miles)
100	56,000	1.1	29
10	104,000	2.0	54
4	126,000	2.4	66
2	144,000	2.8	75
1	162,000	3.1	84
0.1	230.000	4.5	120

The reservoir space required for flood control would vary with the degree of protection desired. An analysis similar to that contained in Bulletin No. 14, of the floods of the period of stream measurement, indicates that to control floods to 100,000 second-feet, reservoir space in excess of 175,000 acre-feet would be required on the average of one day in 100 years and to control to 75,000 second-feet, space in excess of 270,000 acre-feet would be required for the same average interval of time. The space required for other average intervals of time is given in the following table. By controlling floods to 100,000 second-feet or less, the overflow area on the lower American River could be protected by levees of economic height placed near the banks of the existing channel.

Maximum controlled flow in second-feet	Reservoir space required to control floods at Fairoaks gaging station, in acre-feet				
	Exceeded one day in 1000 years	Exceeded one day in 100 years	Exceeded one day in 50 years	Exceeded one day in 25 years	Exceeded one day in 10 years
75,000	410,000	270,000	235,000	190,000	125,000
100,000	310,000	175,000	140,000	100,000	15,000

It is proposed to reserve an aggregate space of 500,000 acre-feet in the reservoirs of the consolidated plan for flood control, divided among the reservoirs as follows: Folsom, 175,000 acre-feet; Auburn, 200,000 acre-feet; and Coloma, 125,000 acre-feet. The sizes of floods with flow characteristics of the March, 1928, flood, controllable with these amounts of reservoir space in the reservoirs of the progressive consolidated development are given in the following table for two maximum controlled flows, 75,000 and 100,000 second-feet.

Stage of development	Maximum space reserved for flood control in acre-feet	Maximum controlled flow at Fairoaks gaging station, in second-feet	Crest discharge of flood controllable	
			In second-feet	In per cent of crest discharge of March, 1928, flood
Folsom alone	175,000	75,000	184,000	100
		100,000	225,000	122
Folsom and Auburn reservoirs	375,000	75,000	260,000	141
		100,000	300,000	163
Folsom, Auburn and Coloma reservoirs	500,000	75,000	300,000	163
		100,000	340,000	185

Rules have been evolved for the operation of the reservoirs of the consolidated development for flood control coordinately with conservation without materially impairing their conservation values. The rule for a maximum controlled flow of 100,000 second-feet at Fairoaks gaging station is as follows:

> Some space be held in reserve for flood control from December 1 to May 1 in each flood season whenever the total precipitation up to any date in the season is more than 50 per cent of the precipitation to the same date in a normal season. The flood control reserve would be increased at a uniform rate from zero on December 1, the beginning of the flood season, to the maximum reservation for flood control on January 1. This maximum space would be held in reserve from January 1 to April 1 and then decreased at a uniform rate to zero on May 1. This space would be maintained as nearly as possible without exceeding the maximum controlled flow of 100,000 second-feet measured at the Fairoaks gaging station of United States Geological Survey. Precipitation to be measured at the cooperative rainfall station of the United States Weather Bureau at Folsom.

By employing 175,000 acre-feet of space for flood control in the Folsom reservoir and providing adequate flood control works in the dam to insure a discharge of 100,000 second-feet and a leveed channel of adequate capacity on the lower American River, greater protection would be afforded the overflow area than with either the plan recommended by the California Debris Commission or the plan which would provide a channel of capacity of 180,000 second-feet with a clearance of 3 feet on the levees, without supplementary reservoir control. A still greater degree of protection would be obtainable with the reservation of additional space for flood control in the Auburn and Coloma reservoirs. The reduction of the flood flows by supplementary reservoir control would also increase the safety of the levee system on the Sacramento River below the mouth of the American.

The reservoirs of the consolidated development could be operated coordinately for flood control and conservation without materially impairing their conservation values. The results of the studies for the period 1905–1927, indicate that the Folsom reservoir could be operated primarily for power generation and to control floods to a maximum controlled flow of 100,000 second-feet utilizing a maximum reservation of 175,000 acre-feet for flood control in the reservoir, without loss in power output. The greatest loss in power output in the several analyses was 1.2 per cent for the complete development, operated primarily for power generation with water released in accord with schedule proposed by the American River Hydro-electric Company, and utilizing an aggregate space of 500,000 acre-feet for flood control in the reservoirs for controlling floods to 100,000 second-feet. The effect of flood control on the yield of the reservoirs in irrigation supply would be negligible. In the analysis of the complete development, the irrigation supply remained the same but the average deficiency in seasonal supply was increased 1.0 per cent.

Salinity control.

During months of low flow in the tributary rivers, salty water from Suisun Bay is carried by the tides into the channels of the delta of the Sacramento and San Joaquin rivers, and mixed with the fresh water from which the irrigated lands of the reclaimed islands obtain their water supply. By means of storage of flood waters in mountain reservoirs and their subsequent release at the proper time and in sufficient volume to supplement the low flow, the incursion of salinity into the delta could be controlled.

The rate, time, and amount of release in total, in any season would vary with the point and degree of control and with the normality of the season. Preliminary studies indicate that a sustained fresh water inflow into the delta of 5000* second feet would control salinity at Antioch to a mean daily salinity of about 100 parts of chlorine per 100,000 parts of water and meet the present irrigation demands in the delta. The total amount of release from the reservoirs to supplement the natural low water inflow would vary with the season. In 1924, 766,000 acre-feet would have been required; in 1920, 465,000 acre-feet; and in 1927, practically none. The greater part of these releases would have occurred in the months of July, August and September. The salinity content at points upstream, however, would be less than at Antioch, decreasing progressively upstream. With control to 100 parts of chlorine per 100,000 parts of water at Antioch, nine-tenths of the delta area would have a water supply with a salinity content less than one-third of the content at Antioch.

The reservoirs of the consolidated development could be utilized for salinity control. By the reservation of a total of 797,000 acre-feet, including an allowance for evaporation, of stored water in the major reservoirs, and released only as needed to meet the demands of salinity control, an inflow into the delta area could be maintained at 5000 second-feet, in a year like 1924, based on present irrigation and channel conditions in the delta and on present irrigation and storage developments in the Sacramento and San Joaquin drainage basins.

The power and irrigation yields of the reservoirs operated coordinately for salinity control by maintaining an inflow of 5000 second-feet into the delta of the Sacramento and San Joaquin rivers, would be

* The rate of inflow of 5000 second feet may be considered as tentative only and may be modified as a result of an intensive investigation of salinity which is now in progress for the 1929 season. This investigation comprehends in addition to the regular salinity observations, that have been made during the past several years, special salinity surveys, stream flow measurements in the delta channels, tidal surveys and detailed analytical studies of the data thus procured from which it is anticipated that definite conclusions as to the behavior of salinity and the relation of salinity to fresh water inflow and to tidal action may be obtained. However, the preliminary estimates of rate and volume of supplementary fresh water inflow as used in this report are believed to be sufficiently accurate for the purpose of estimating reservoir capacities and releases required for salinity control. Since the consumptive use of water in the delta varies from month to month, increasing during the irrigation season, the fresh water inflow necessary to control salinity to any point and degree would have a monthly variation. For the purposes of the study contained herein, a uniform rate of 5000 second feet has been assumed.

impaired to some extent, as indicated by studies for the period 1905–27. With the reservoirs of the complete development operated primarily for power generation with schedule of water release to develop maximum primary power consistent with controlling salinity at Antioch, by maintaining an inflow of 5000 second-feet into the delta, the average annual power output would have been reduced from 689,500,000 kilowatt hours without salinity control, to 652,900,000 kilowatt hours with salinity control, or 5.3 per cent. If the water were released from the reservoirs primarily for power generation in accord with schedule proposed by American River Hydro-electric Company, modified, however, to be consistent with salinity control requirements to same degree and point of control, the average annual power output would have been reduced from 773,100,000 kilowatt hours without salinity control, to 742,500,000 kilowatt hours, with salinity control, or 4.0 per cent. The maximum irrigation yield obtainable from the development, assuming an average seasonal deficiency in the irrigation supply of 2.2 per cent of a perfect seasonal supply for the period 1905–27, would have been diminished from 1,757,000 acre-feet per season without salinity control to 1,070,000 acre-feet per season or 39.1 per cent.

Some degree of salinity control could be obtained through the operation of the reservoirs primarily for power generation, however, to insure control to any particular degree and point of control, the reservoirs must be operated specifically for salinity control purposes.

Methods of operating complete consolidated development coordinately for flood control, salinity control, irrigation and power.

An opportunity is afforded with the complete consolidated development to operate the major reservoirs with an aggregate capacity of 1,719,000 acre-feet coordinately for flood control, salinity control, irrigation and power and obtain a substantial value for each use. One method of operation, based on an analysis of the period 1905–27, would have resulted in the following accomplishments:

1. Floods controlled on American River to 100,000 second-feet maximum flow measured at the Fairoaks gaging station of the United States Geological Survey.
2. Inflow into the delta of Sacramento and San Joaquin rivers maintained at 5000 second-feet for salinity control and to meet the irrigation demands of the delta area.
3. An irrigation supply of 334,000 acre-feet per season (1000 second-feet maximum rate of flow) made available for San Joaquin Valley, without deficiency in supply.
4. A power output of 632,300,000 kilowatt hours per year, of which the primary power output would have been 340,800,000 kilowatt hours.

Although the irrigation supply is designated for the San Joaquin Valley, it could as well have been for the local areas adjacent to the American River, however, there would have been a slight difference in the monthly distribution of the irrigation demand. Existing prior rights for irrigation along the American River downstream from the Folsom dam are included in the estimates.

If the irrigation supply to the San Joaquin Valley or to the local areas were increased to 1,000,000 acre-feet, floods on the American River still could be controlled to 100,000 second-feet, and an inflow of 5000 second-feet into the delta maintained. For the period, 1905–27, the power output, however, would have been reduced to 585,700,000 kilowatt hours per year and would have been seasonal in character and the irrigation supply would have had a deficiency of 32 per cent of a perfect seasonal supply in 1924. In order to furnish a perfect supply in a year like 1924, larger reservoir capacity would be required. In this study the operation of the existing Folsom City power plant was subordinated to the operation of the reservoirs of the consolidated development and as in the previous study existing prior rights along the American River are included in the estimates.

Effect of the operation of the consolidated development on navigation on Sacramento River.

Through the operation of the units of the consolidated development, navigation conditions in general would be improved on the Sacramento River below the mouth of the American River. The extent of the improvement would be dependent on the stage of the development and the method employed in operating the reservoirs. The following table gives the average flow in the months of low flow for the years 1924–1927, inclusive, compared with the average flow in the same months, had the reservoirs of the consolidated development been in operation. The figures given in the table are based on the assumption that no water would have been diverted from the American River below the Folsom dam. If water were diverted, these figures would be reduced by the amount of the diversion for any particular month in a season. With Folsom reservoir operated alone to develop maximum primary power, the average flow in July, 1924, would have been increased from 910 to 1760 second-feet and with Folsom, Auburn and Coloma reservoirs operated to develop maximum primary power consistent with maintaining an inflow into the delta of the Sacramento and San Joaquin rivers for salinity control, the average flow in the same month would have been 4580 second-feet.

EFFECT OF THE OPERATION OF CONSOLIDATED DEVELOPMENT ON NAVIGATION ON SACRAMENTO RIVER

Year and month	Average Flow of Sacramento River at Sacramento, in Second-feet								
		With Consolidated Development in Operation							
		Initial development—Folsom reservoir alone		Second stage of development—Folsom and Auburn reservoirs		Third stage of development—Folsom, Auburn and Coloma reservoirs			
	Without consolidated development in operation	Operated to develop maximum primary power	Operated in accord with schedule of water release proposed by American River Hydro-electric Company	Operated to develop maximum primary power	Operated in accord with schedule of water release proposed by American River Hydro-electric Company	Operated to develop maximum primary power	Operated in accord with schedule of water release proposed by American River Hydro-electric Company	Operated to develop maximum primary power consistent with maintaining an inflow of 5,000 second-feet into delta of Sacramento and San Joaquin rivers for salinity control	Operated to develop maximum primary power consistent with maintaining an inflow of 5,000 second-feet into delta of Sacramento and San Joaquin rivers for salinity control and supplying 334,000 acre-feet per year (1,000 second-feet maximum rate of flow) to San Joaquin Valley
1924									
June	1,320	2,120	1,320	2,630	1,280	3,290	3,710	4,420	5,430
July	910	1,760	910	2,290	870	2,970	3,290	4,580	5,560
August	1,370	2,260	1,370	2,810	1,330	3,490	1,640	4,730	5,390
September	2,700	3,590	2,700	4,100	2,670	4,740	2,700	4,620	5,140
1925									
July	4,680	4,610	5,600	4,950	6,120	5,440	6,120	5,180	6,090
August	3,030	3,600	4,710	4,050	5,180	4,560	5,180	4,520	4,990
September	4,640	5,240	6,360	5,670	6,830	6,150	6,830	5,900	5,610

1926									
July	1,880	2,540	3,650	2,970	4,110	3,460	4,110	4,230	5,200
August	1,980	2,800	3,810	3,230	4,310	3,720	4,310	4.400	5,210
September	4,670	5,450	5,100	5,850	6,520	6,300	6,960	7,120	7,420
1927									
July	6,150	6,080	6,910	6,220	7,400	6,720	7,400	6,470	6,190
August	3,660	4,200	5,280	4,640	5,770	5,150	5,770	4,890	4,590
September	5,100	5,680	6,770	6,110	7,280	6.590	7,280	6,340	6,050

Capital cost.

The estimated cost* of the consolidated development is set forth in the following two tables. In the first table are given the costs for the five reservoir units with power plants installed for a plant load factor of 0.75 with both state and private financing; interest during construction at 4½ and 6 per cent, respectively. The figures for the Folsom reservoir represent the costs for that unit in the ultimate development. In the footnote, are given figures for corresponding items for the initial development (Folsom reservoir alone). In the second table, corresponding figures are given for the development with the power installations as proposed by the American River Hydro-electric Company. Details of all these estimates are tabulated in Chapter IX.

* The estimated costs contained herein are preliminary. The costs of dams are based on a gravity-concrete section that is considered adaptable to good foundation conditions. Detailed exploratory work and further study might alter the type and section of dam finally selected for any particular site, resulting in a variation from these estimates.

COST OF CONSOLIDATED DEVELOPMENT
With power installation on plant load factor = 0.75

Unit	State financing Interest during construction at 4½ per cent per annum				Private financing Interest during construction at 6 per cent per annum			
	Dam and reservoir	Power plant	Additional cost for flood control features	Total cost	Dam and reservoir	Power plant	Additional cost for flood control features	Total cost
Folsom reservoir*	$8,329,000	$3,390,000	$563,000	$12,282,000	$8,478,000	$3,444,000	$573,000	$12,495,000
Auburn reservoir	13,125,000	3,633,000	447,000	17,205,000	13,396,000	3,686,000	454,000	17,536,000
Pilot Creek reservoir	939,000	1,024,000	0	1,965,000	949,000	1,035,000	0	1,984,000
Coloma reservoir	10,546,000	1,998,000	252,000	12,796,000	10,793,000	2,035,000	256,000	13,084,000
Webber Creek reservoir	590,000	838,000	0	1,428,000	596,000	847,000	0	1,443,000
Totals	$33,529,000	$10,883,000	$1,262,000	$45,674,000	$34,212,000	$11,047,000	$1,283,000	$46,542,000

*Cost of various items for initial development (Folsom reservoir alone) would be as follows:

State financing:		Private financing:	
Dam and reservoir	$8,329,000	Dam and reservoir	$8,478,000
Power plant	2,797,000	Power plant	2,842,000
Additional cost for flood control features	558,000	Additional cost for flood control features	568,000
Total cost	$11,684,000	Total cost	$11,888,000

COST OF CONSOLIDATED DEVELOPMENT

With power installation as proposed by American River Hydro-electric Company

Unit	State financing Interest during construction at 4½ per cent per annum				Private financing Interest during construction at 6 per cent per annum			
	Dam and reservoir	Power plant with plant load factor =0.60*	Additional cost for flood control features	Total cost	Dam and reservoir	Power plant with plant load factor =0.60*	Additional cost for flood control features	Total cost
Folsom reservoir†	$8,329,000	$2,949,000	$563,000	$11,841,000	$8,478,000	$2,997,000	$573,000	$12,048,000
Auburn reservoir	13,125,000	4,357,000	447,000	17,929,000	13,396,000	4,418,000	454,000	18,268,000
Pilot Creek reservoir	939,000	1,205,000	0	2,144,000	949,000	1,218,000	0	2,167,000
Coloma reservoir	10,516,000	2,220,000	252,000	13,018,000	10,793,000	2,256,000	256,000	13,305,000
Webber Creek reservoir	590,000	973,000	0	1,563,000	596,000	984,000	0	1,580,000
Totals	$33,529,000	$11,704,000	$1,262,000	$46,495,000	$34,212,000	$11,873,000	$1,283,000	$47,368,000

*Plant load factor for Folsom plant =1.00.

†Cost of various items for initial development (Folsom reservoir alone) would be as follows:

State financing:	
Dam and reservoir	$8,329,000
Power plant	2,400,000
Additional cost for flood control features	558,000
Total cost	$11,287,000
Private financing:	
Dam and reservoir	$8,478,000
Power plant	2,441,000
Additional cost for flood control features	568,000
Total cost	$11,487,000

Annual cost.

The estimated annual cost of the three stages of the consolidated development are given in the two following tables, for several modes of reservoir operation, both with and without inclusion of flood control features and under both state and private financing. In the first table, data are given with a power plant installation for a plant load factor of 75 per cent and in the second table with an installation proposed by the American River Hydro-electric Company. The annual costs are expressed both in per cent of the capital cost and in mills per kilowatt hour of power produced under the various conditions. Under private financing and operation, the annual costs are given both excluding and including state taxes. Explanation of the methods employed in arriving at the annual costs are set forth in detail in Chapter X. The annual costs for other methods of reservoir operation and those given in the following tables are also set forth in Chapter X.

ANNUAL COST OF CONSOLIDATED DEVELOPMENT WITH POWER INSTALLATION ON PLANT LOAD FACTOR OF 0.75

Method of reservoir operation	Average annual power output in kilowatt hours	State financing and operation				Private financing and operation						
		Capital cost	Annual cost	Annual cost in per cent of capital cost	Annual cost per kilowatt hour produced, in mills	Capital cost	Annual cost		Annual cost in per cent of capital cost		Annual cost per kilowatt hour produced, in mills	
							Excluding state taxes	Including state taxes	Excluding state taxes	Including state taxes	Excluding state taxes	Including state taxes
Initial Development (Folsom reservoir and power plant)												
Power (developing maximum primary power)	153,700,000	$11,126,000	$745,000	6.7	4.9	$11,320,000	$1,011,000	$1,163,000	8.9	10.3	6.6	7.6
Power and flood control (developing maximum primary power consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks)	153,700,000	11,684,000	781,000	6.7	5.1	11,888,000	1,061,000	1,222,000	8.9	10.3	6.9	8.0
Irrigation with incidental power (irrigation yield of 664,000 acre-feet per season, with an average deficiency in seasonal supply of 2.2 per cent of perfect seasonal supply)	143,700,000	11,126,000	745,000	6.7	5.2	11,320,000	1,011,000	1,163,000	8.9	10.3	7.0	8.1
Irrigation and flood control with incidental power (irrigation yield of 664,000 acre-feet per season with an average deficiency in seasonal supply of 2.2 per cent of perfect seasonal supply. Floods controlled to 100,000 second-feet maximum flow at Fairoaks)	143,700,000	11,684,000	781,000	6.7	5.4	11,888,000	1,061,000	1,222,000	8.9	10.3	7.4	8.5
Second Stage of Development (Folsom, Auburn and Pilot Creek reservoirs and power plants)												
Power (developing maximum primary power)	481,100,000	30,440,000	2,068,000	6.8	4.3	30,988,000	2,793,000	3,211,000	9.0	10.4	5.8	6.7
Power and flood control (developing maximum primary power consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks)	481,100,000	31,450,000	2,130,000	6.8	4.4	32,015,000	2,881,000	3,313,000	9.0	10.4	6.0	6.9

Irrigation with incidental power (irrigation yield of 1,250,000 acre-feet per season, with an average deficiency in seasonal supply of 2.1 per cent of perfect seasonal supply)..	416,000,000	30,440,000	2,068,000	6.8	5.0	30,988,000	2,793,000	3,211,000	9.0	10.4	6.7	7.7
Complete Development (Folsom, Auburn, Pilot Creek, Coloma and Webber Creek reservoirs and power plants)												
Power (developing maximum primary power)....	689,500,000	44,412,000	2,984,000	6.7	4.3	45,259,000	4,053,000	4,664,000	9.0	10.3	5.9	6.8
Power and flood control (developing maximum primary power consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks)..	689,500,000	45,674,000	3,065,000	6.7	4.5	46,542,000	4,163,000	4,791,000	8.9	10.3	6.0	7.0
Power, flood control and salinity control (developing maximum primary power consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks and maintaining an inflow into the delta of the Sacramento and San Joaquin rivers of 5,000 second-feet for salinity control)................	652,900,000	45,674,000	3,065,000	6.7	4.7	46,542,000	4,163,000	4,791,000	8.9	10.3	6.4	7.3
Power, flood control, salinity control and irrigation supply of 1,000 second-feet to San Joaquin valley (developing maximum primary power consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks, maintaining an inflow into the delta of the Sacramento and San Joaquin rivers of 5,000 second-feet for salinity control, and an irrigation supply of 334,000 acre-feet per season, 1,000 second-feet maximum rate of flow to San Joaquin Valley).........	632,300,000	45,674,000	3,065,000	6.7	4.8	46,542,000	4,163,000	4,791,000	8.9	10.3	6.6	7.6

ANNUAL COST OF CONSOLIDATED DEVELOPMENT WITH POWER INSTALLATION AS PROPOSED BY AMERICAN RIVER HYDRO-ELECTRIC COMPANY

Method of reservoir operation	Average annual power output in kilowatt hours	State financing and operation				Private financing and operation						
		Capital cost	Annual cost	Annual cost in per cent of capital cost	Annual cost per kilowatt hour produced, in mills	Capital cost	Annual cost		Annual cost in per cent of capital cost		Annual cost per kilowatt hour produced, in mills	
							Excluding state taxes	Including state taxes	Excluding state taxes	Including state taxes	Excluding state taxes	Including state taxes
Initial Development (Folsom reservoir and power plant)												
Power (with water release in accord with schedule proposed by American River Hydro-electric Company)	160,200,000	$10,729,000	$711,000	6.6	4.4	$10,919,000	$970,000	$1,117,000	8.9	10.2	6.1	7.0
Power and flood control (with water release in accord with schedule proposed by American River Hydro-electric Company consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks)	161,100,000	11,287,000	747,000	6.6	4.6	11,487,000	1,018,000	1,173,000	8.9	10.2	6.3	7.3
Second stage of Development (Folsom, Auburn and Pilot Creek reservoirs and power plants)												
Power (with water release in accord with schedule proposed by American River Hydro-electric Company)	569,200,000	30,904,000	2,108,000	6.8	3.7	31,456,000	2,844,000	3,269,000	9.0	10.4	5.0	5.7
Power and flood control (with water release in accord with schedule proposed by American River Hydro-electric Company consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks)	567,000,000	31,914,000	2,172,000	6.8	3.8	32,483,000	2,932,000	3,370,000	9.0	10.4	5 2	5.9

Complete Development (Folsom, Auburn, Pilot Creek, Coloma and Webber Creek reservoirs and power plants)												
Power (with water release in accord with schedule proposed by American River Hydro-electric Company)............	773,100,000	45,233,000	3,060,000	6.8	4.0	46,085,000	4,143,000	4,765,000	9.0	10.3	5.4	6.2
Power and flood control (with water release in accord with schedule proposed by American River Hydro-electric Company consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks)...	764,200,000	46,495,000	3,139,000	6.8	4.1	47,368,000	4,254,000	4,893,000	9.0	10.3	5.6	6.4
Power and salinity control (with water release in accord with schedule proposed by American River Hydro-electric Company consistent with maintaining an inflow into the delta of the Sacramento and San Joaquin rivers of 5,000 second-feet for salinity control)...............	742,500,000	45,233,000	3,060,000	6.8	4.1	46,085,000	4,143,000	4,765,000	9.0	10.3	5.6	6.4
Power, flood control and salinity control (with water release in accord with schedule proposed by American River Hydro-electric Company consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks and maintaining an inflow into the delta of the Sacramento and San Joaquin rivers of 5,000 second-feet for salinity control)...............	741,200,000	46,495,000	3,139,000	6.8	4.2	47,368,000	4,254,000	4,893,000	9.0	10.3	5.7	6.6

Revenue from power.

The revenue that may be obtained from the sale of electric power produced at the power plants of the consolidated development for the three stages of the development and for the various modes of reservoir operation, will depend on many conditions which are not known at this time or possible of being definitely established. Although the power output has been estimated and its characteristics have been determined for the period 1905–1927, under assumed methods of reservoir operation, the actual method of operation might vary materially from those assumed in the report, resulting in a different amount of power output and in quite different power characteristics. This condition is particularly true of the operations for the generation of power but applies to a lesser degree to the operations to secure flood control, salinity control and an irrigation supply. The conditions under which the power would be produced, the condition of the general power market relative to its ability to absorb the power produced, the cost of power from other and competing sources and other conditions pertaining to the disposal of the power at the time it would come on the market, are important and unknown elements which would affect the revenue from power that could be expected from the development. In view of these conditions not being fixed, it is not possible to determine with any degree of certainty, the revenue that would be obtained from disposal of the power produced.

CHAPTER II

DRAINAGE BASIN AND WATER SUPPLY OF AMERICAN RIVER

Drainage basin.

The American River is the second largest stream tributary to the Sacramento River below Red Bluff, being exceeded in size only by the Feather. It rises in the crest of the Sierra Nevada Mountains and drains 1919 square miles of mountainous area. Three main forks, North, Middle and South, join above the valley floor to form the main stream which discharges into the Sacramento River at the city of Sacramento. The geographic location and extent of the drainage basin are delineated on Plate II.

Elevations in the watershed vary from about 100 feet at Fairoaks gaging station to over 10,000 feet at Pyramid Peak and Round Top, on the crest of the Sierra Nevada divide. The following table shows the distribution of areas between various elevations.

TABLE 1. ELEVATION OF AMERICAN RIVER DRAINAGE BASIN ABOVE FAIROAKS GAGING STATION

Elevation above sea level	Drainage area	
	In square miles	In per cent of total drainage area
Below 2,500 feet	524	27.3
Between 2,500 and 5,000 feet	600	31.3
Above 5,000 feet	795	41.4
Totals	1,919	100.0

Precipitation on the watershed varies from a mean seasonal of 25 inches in the lower areas to about 70 inches at elevations of 4000 to 5000 feet.

Water supply.

The run-off of the American River has been measured continuously at the Fairoaks gaging station of the United States Geological Survey since 1904. In order to obtain the unimpaired flow at this station, the measurements were corrected for upstream diversions, storage and contributions for the period during which these various conditions existed.

The principal diversions are the Towle and North Fork ditches on the North Fork, the Pilot Creek ditch on the Middle Fork and the Eldorado, Webber Creek and Natomas ditches on the South Fork and the Alder Creek pumping plant on the main stream. The amounts diverted by these ditches were added to the measured flow in obtaining the unimpaired flow. The measured flow was corrected also for storage and release from reservoirs on the head waters of the tributaries; namely, Echo, Medley Lakes, Twin Lakes, Silver Lake and Webber Creek on the South Fork drainage, Lake Valley on the North Fork and Loon Lake on the Middle Fork with an aggregate capacity of about 50,000 acre-feet.

The Pacific Gas and Electric Company, through its South Canal, diverts from the tailrace of the Wise power plant into the North Fork of the American River, water originating on areas outside of the American River watershed. This contribution was deducted from the measurements in obtaining the unimpaired flow.

In Table 2, the seasonal run-offs measured at the Fairoaks gaging station, expressed in acre-feet and those unimpaired by upstream diversions, storage and contributions, in acre-feet and acre-feet per square mile, are set forth for the period 1904–1927. The figures show a wide variation in seasonal run-off. The maximum run-off occurred in the season of 1906–07, with 5,783,000 acre-feet and the minimum in 1923–24, with 551,000 acre-feet, 196 per cent and 18.7 per cent, respectively, of the average for the period 1904–27 of 2,953,000 acre-feet.

TABLE 2. SEASONAL RUN-OFF OF AMERICAN RIVER AT FAIROAKS GAGING STATION
1904-1927

Season (October 1 to September 30)	Seasonal run-off		
	Measured at Fairoaks gaging station in acre-feet	Unimpaired by upstream diversions and contributions	
		In acre-feet	In acre-feet per square mile
1904-05	1,955,000	2,050,000	1,068
1905-06	4,763,000	4,836,000	2,520
1906-07	5,710,000	5,783,000	3,014
1907-08	1,454,000	1,527,000	796
1908-09	4,549,000	4,623,000	2,409
1909-10	3,542,000	3,615,000	1,884
1910-11	5,481,000	5,555,000	2,895
1911-12	1,264,000	1,336,000	696
1912-13	1,434,000	1,542,000	804
1913-14	3,951,000	4,072,000	2,122
1914-15	3,061,000	3,180,000	1,657
1915-16	3,848,000	3,965,000	2,066
1916-17	2,832,000	2,948,000	1,536
1917-18	1,420,000	1,541,000	803
1918-19	2,155,000	2,266,000	1,181
1919-20	1,391,000	1,502,000	783
1920-21	3,223,000	3,212,000	1,674
1921-22	3,349,000	3,286,000	1,712
1922-23	2,750,000	2,757,000	1,437
1923-24	530,000	551,000	287
1924-25	2,759,000	2,726,000	1,421
1925-26	1,374,000	1,391,000	726
1926-27	3,628,000	3,612,000	1,898
Average, 1904-27	2,890,000	2,953,000	1,539

The distribution of the seasonal run-off among the months also has a wide variation. In Table 3, the average for the period of stream measurement is shown for each month of the year. It may be observed that, on the average, the maximum occurs in May and the minimum in September, with 19.8 per cent and 0.5 per cent, respectively, of the seasonal total.

TABLE 3. AVERAGE MONTHLY DISTRIBUTION OF SEASONAL RUN-OFF 1904-1927

Month	Run-off by months	
	In acre-feet	In per cent of seasonal total
October	25,000	0.9
November	60,000	2.0
December	120,000	4.1
January	315,000	10.7
February	367,000	12.4
March	434,000	14.7
April	526,000	17.8
May	585,000	19.8
June	376,000	12.7
July	104,000	3.5
August	25,000	0.9
September	16,000	0.5
Totals	2,953,000	100.0

An examination of the daily discharge records at the Fairoaks gaging station of the United States Geological Survey, discloses a greater variation in the daily run-off than for the seasonal and monthly values. The greatest recorded daily discharge occurred on March 25, 1928, when the flow reached a crest discharge of 184,000 second-feet. The mean for the day was 120,000 second-feet. The minimum flow of record occurred in 1924, when the flow dropped to 5 second-feet for three weeks in July and August.

CHAPTER III

CONSOLIDATED PLAN OF DEVELOPMENT ON AMERICAN RIVER PROPOSED BY AMERICAN RIVER HYDRO-ELECTRIC COMPANY

General.

The plans of the American River Hydro-electric Company call for an extensive reservoir and power development on the lower American River. They include the construction of three major and two minor reservoirs, together with power plants at the dams for production of electric power. The locations of the various units of the development are delineated on Plate II. It may be observed that the reservoirs are strategically located to control the run-off of practically the entire watershed of the American River.

The reservoirs have large capacity in aggregate. The major reservoirs, Folsom on the main stream, Auburn on the North Fork and Coloma on the South Fork, have a total storage capacity of 1,719,000 acre-feet, 58 per cent of the average annual run-off of the American River for the period 1904–1927. The two minor reservoirs, Pilot Creek, located on the North Fork between the Folsom and Auburn reservoirs, and Webber Creek, below the Coloma reservoir on the South Fork, have relatively small capacity and would be utilized primarily for creation of power head. However, a part of their capacity, if so desired, could be used for re-regulating the daily fluctuations in the water release from the upstream major reservoirs.

A substantial power drop may be obtained from the development as indicated on Plate III. The water level of the uppermost reservoir is 900 feet and the elevation of the tailrace of the lowest power plant is 162 feet. On the North Fork, 495 feet of power head would be developed, on the South Fork 445 feet and on the main stream from 190 to 228 feet, depending on the plant layout at the Folsom dam. A total power installation of 200,000 k.v.a. P.F.=0.80 is proposed by the American River Hydro-electric Company. With this installation an average output of 88,250 kilowatts of electric power would be produced if operated primarily for power generation.

Folsom reservoir.

Two sites, about 2000 feet apart, have been proposed for the dam of the Folsom reservoir. Both are located about two miles upstream from the town of Folsom and above the diversion dam of the Pacific Gas and Electric Company. The upper site was used for the estimates set forth in Bulletin No. 12, "Summary Report on the Water Resources of California and a Coordinated Plan for Their Development," published by the Division of Engineering and Irrigation. The lower site has been selected by the American River Hydro-electric Company for its proposed development. Studies indicate that both sites are essentially equal as regards foundation, unit cost of storage, and total potential power output of the stream. The lower site has been used in the studies for this report. This site is located in section 24, T. 10 N., R. 7 E., M. D. B. and M., about two miles upstream from the town of Folsom and one mile below the junction of the North and South forks. The dam would rise 190 feet above the streambed elevation of 205 feet with a crest length of 5280 feet, and would back water up both forks, flooding 6460 acres of land to elevation 390 feet and impounding 355,000 acre-feet of water.

The site has been extensively explored by the American River Hydro-electric Company. Hyde Forbes, geologist, has examined the site and the cores of the diamond drill explorations. He reports that the foundation is granite and is suitable for the dam proposed, provided it is properly sealed by grouting. His report on this and the dam sites for the other reservoirs is given in full in Chapter XI of this report.

Two auxiliary dams would be required on the rim of the reservoir. These would be low earthen embankments located in sections 28 and 29, T. 10 N., R. 8 E., and in section 13, T. 10 N., R. 7 E., M. D. B. and M., respectively.

The lands and improvements within the reservoir area are important items to be considered in the construction of the Folsom reservoir. The lands comprise both agricultural and grazing, with the area used for grazing predominating. Although the net area flooded is 6460 acres, a considerably larger acreage would probably have to be acquired in carrying out the development. The two most important improvements that would be flooded are the Natomas and the North Fork canals. Each has a capacity of about 60 second-feet. The Natomas canal heads on the South Fork near Salmon Falls, below the Webber Creek and Coloma dam sites and supplies water to gold dredgers and agricultural lands in the vicinity of Folsom. The North Fork canal diverts from the North Fork below the Auburn dam site at a point about 17 miles upstream from the junction of the North and South forks. It serves an agricultural area on the north side of the American River in and around Fair-oaks. These canals could be relocated above the flow line of the reservoir. Other improvements that would be submerged and would require relocation are county roads and bridges and a power line which traverses the reservoir site. The cost of acquiring the lands and marginal areas required for the reservoir site and removing all improvements within the reservoir area is estimated at $1,500,000, or equal to 18 per cent of the total cost of dam and reservoir.

Based on the topographic maps and data furnished by the American River Hydro-electric Company, reservoir areas and capacities for the several heights of dam have been calculated and are tabulated as follows:

TABLE 4. CAPACITY OF FOLSOM RESERVOIR

Height of dam, in feet (5 feet freeboard)	Water surface elevation of reservoir, in feet	Area of water surface, in acres	Capacity of reservoir, in acre-feet
80	280	920	29,000
90	290	1,150	39,500
100	300	1,400	52,200
110	310	1,600	67,700
120	320	1,980	85,600
130	330	2,350	107,300
140	340	2,800	133,000
150	350	3,300	163,800
160	360	3,900	200,000
170	370	4,610	242,500
180	380	5,460	293,800
190	390	6,460	355,000

The Folsom reservoir is particularly well situated to control the run-off from the American River watershed, since practically all of it originates above the dam site. The unimpaired run-off above the Folsom reservoir is estimated to be 0.14 per cent less than the unimpaired run-off at the Fairoaks gaging station; however, it is not all available for use at the Folsom dam. It is reduced by the upstream diversions from the tributaries. At the present time, diversions are made in six principal ditches. These are Towle and North Fork ditches on the North Fork, Pilot Creek on the Middle Fork, and Eldorado, Webber Creek and Natomas on the South Fork. These diversions are made for domestic, irrigation, power and mining uses. The total amount diverted in a season based on fragmentary records is estimated at about 117,000 acre-feet. All of these waters are diverted above the Folsom dam site. Table 5 sets forth for each diversion, source of supply, estimated amount of water diverted annually and use to which it is put:

TABLE 5. PRESENT DIVERSIONS FROM AMERICAN RIVER ABOVE FOLSOM DAM

Diversion	Source of supply	Estimated amount diverted annually, in acre-feet	Use
Towle ditch	North Fork of American River	*13,000	Power and irrigation.
North Fork ditch	North Fork of American River	40,000	Irrigation and domestic.
Pilot Creek ditch	Middle Fork of American River	*4,000	Irrigation and domestic.
Eldorado ditch	South Fork of American River	*15,000	Irrigation and domestic.
Webber Creek ditch	South Fork of American River	*4,000	Irrigation.
Natomas ditch	South Fork of American River	41,000	Irrigation and mining.
Total		117,000	

*Supplies irrigation and domestic demands in foothill areas.

In addition to the diversions set forth in the preceding table, water will be required at some future time for the development of foothill agricultural areas other than those now under irrigation above the Folsom reservoir. These lands lie within and adjacent to the American River watershed. From all the data available, it is estimated that, including the present irrigated foothill areas, about 200,000 acres are irrigable from American River. This area is shown in brown on Plate II and includes about 50,000 acres, which by reason of topographic conditions and physical obstacles to be overcome in obtaining a water supply, could be more economically served from a source outside the American River basin. Therefore, there is a gross area of 150,000 acres of foothill agricultural lands, including those now receiving a supply, that probably at some future time will look to the American River for a water supply to the extent of about 200,000 acre-feet per year.

In estimating the water supply for the power and irrigation studies presented herein, 21,000 acre-feet have been set aside for irrigation expansion on these foothill areas in the near future.

Below the Folsom dam, there are a number of pumping diversions that aggregate about 25,000 acre-feet per season.

The present maximum upstream diversions, estimated at 117,000 acre-feet and given in Table 5, and the estimated requirement for irrigation expansion in the near future of 21,000 acre-feet, make a total of 138,000 acre-feet that would be diverted above the Folsom dam. The Pacific Gas and Electric Company diverts, through its South Canal, water from the tailrace of the Wise power plant on Auburn Ravine. The canal, after serving a small area between Auburn Ravine and the American River, delivers its surplus into the American River. This water originates on an area outside of the American River watershed. The power and irrigation estimates at the Folsom dam are based on a water supply including this foreign water which amounts to an average of 108,000 acre-feet per year. The above contribution combined with the upstream present and near future use results in a net diversion of 30,000 acre-feet per year. If this water were excluded from the supply, only a slight reduction in the estimates would be required.

Table 6 gives, from 1904 to 1927, the seasonal run-offs in acre-feet, above the Folsom dam, unimpaired by upstream diversions and contributions, available for power development and available for new irrigation use below the dam.

TABLE 6. ESTIMATED SEASONAL RUN-OFF OF AMERICAN RIVER AT FOLSOM DAM SITE
1904-1927

Season, (October 1 to September 30)	Estimated seasonal run-off				
	Unimpaired by upstream diversions and contributions, in acre-feet	Net upstream diversions including 21,000 acre-feet for immediate expansion in irrigation development and in excess of yearly contribution of 108,000 acre-feet from South Canal of Pacific Gas and Electric Co., in acre-feet	Available for power development, in acre-feet	Prior rights downstream from dam, in acre-feet	Available for new irrigation development, in acre-feet
1904-05	2,047,000	30,000	2,017,000	25,000	1,992,000
1905-06	4,829,000	30,000	4,799,000	25,000	4,774,000
1906-07	5,775,000	30,000	5,745,000	25,000	5,720,000
1907-08	1,525,000	30,000	1,495,000	25,000	1,470,000
1908-09	4,617,000	30,000	4,587,000	25,000	4,562,000
1909-10	3,610,000	30,000	3,580,000	25,000	3,555,000
1910-11	5,547,000	30,000	5,517,000	25,000	5,492,000
1911-12	1,334,000	30,000	1,304,000	25,000	1,279,000
1912-13	1,540,000	30,000	1,510,000	25,000	1,485,000
1913-14	4,066,000	30,000	4,036,000	25,000	4,011,000
1914-15	3,176,000	30,000	3,146,000	25,000	3,121,000
1915-16	3,959,000	30,000	3,929,000	25,000	3,904,000
1916-17	2,944,000	30,000	2,914,000	25,000	2,889,000
1917-18	1,539,000	30,000	1,509,000	25,000	1,484,000
1918-19	2,263,000	30,000	2,233,000	25,000	2,208,000
1919-20	1,500,000	30,000	1,470,000	25,000	1,445,000
1920-21	3,208,000	30,000	3,178,000	25,000	3,153,000
1921-22	3,281,000	30,000	3,251,000	25,000	3,226,000
1922-23	2,753,000	30,000	2,723,000	25,000	2,698,000
1923-24	550,000	30,000	520,000	25,000	495,000
1924-25	2,722,000	30,000	2,692,000	25,000	2,667,000
1925-26	1,392,000	30,000	1,362,000	25,000	1,337,000
1926-27	3,637,000	30,000	3,607,000	25,000	3,582,000
Average, 1904-27	2,948,000	30,000	2,918,000	25,000	2,893,000

Auburn reservoir.

The dam for the Auburn reservoir would be located across the canyon of the North Fork of the American River in section 11, T. 12 N., R. 8 E., M. D. B. and M., 1.4 miles downstream from the junction of the North and Middle forks. It would be 390 feet high, flooding 4206 acres of land up to elevation 900 feet and impounding 598,000 acre-feet of water. The site is a narrow gorge, 150 feet wide at the stream bed with side slopes rising about 0.5 feet per foot of horizontal distance. A geologic examination has been made and report rendered on this site also, by Hyde Forbes. He classifies the foundation rock at this site as amphibolite schist and in conclusion states, "In my opinion, the geological and topographical conditions at this point combine to make an excellent site and foundation for the major structure proposed." This site has not been drilled.

The lands flooded by this reservoir are steep rocky slopes, suitable primarily for grazing purposes. The major improvements within the area of the reservoir are the quarry and branch railroad of the Pacific Portland Cement Company and the highways extending from Auburn to Georgetown and Placerville. The estimated cost of the lands and improvements flooded, including relocation of the highway, is $1,200,000 or equal to 9.0 per cent of the estimated total cost of dam and reservoir.

The location of this reservoir is favorable for regulating a large part of the run-off of the watershed, since its tributary area comprises 50.3 per cent of the entire American River drainage basin upstream from the Fairoaks gaging station.

The area and capacity of the reservoir for several heights of dam are as follows:

TABLE 7. CAPACITY OF AUBURN RESERVOIR

Height of dam, in feet (5 feet freeboard)	Water surface elevation of reservoir, in feet	Area of water surface, in acres	Capacity of reservoir, in acre-feet
30	540	86	900
50	560	148	3,300
70	580	203	6,800
90	600	283	11,600
110	620	426	18,700
130	640	597	29,000
150	660	774	42,700
170	680	968	60,100
190	700	1,244	82,200
210	720	1,467	109,300
230	740	1,692	140,900
250	760	1,937	177,200
270	780	2,200	218,600
290	800	2,508	265,700
310	820	2,804	318,800
330	840	3,143	378,200
350	860	3,480	444,500
370	880	3,830	517,600
390	900	4,206	598,000

The water supply originating above the Auburn dam has been estimated for the period 1904–1927, based on measurements of the United States Geological Survey. Gaging stations have been maintained on the North Fork at Colfax since August 16, 1911, and on the Middle Fork at East Auburn beginning October 22, 1911. These records together with those at Fairoaks have been used in preparing the estimates. By comparing the run-off at these two upper stations and those on the

South Fork at Camino and at Placerville, with that measured at Fairoaks, it was found that inconsistencies exist in the spring months of some years, the measurements at the upper stations totaling more than the run-off measured at the Fairoaks gaging station after allowing for intermediate diversions. In reconciling these differences, the values at the Fairoaks station were assumed to be correct and the values at the upper stations were adjusted to conform.

Table 8 gives, from 1904 to 1927, the estimated seasonal run-offs, unimpaired by upstream diversions and that available for power development after deducting upstream prior rights including 21,000 acre-feet for expansion in irrigation development in the near future. The average unimpaired seasonal run-off is 1,718,000 acre-feet, or 58.2 per cent of total run-off originating above the Fairoaks gaging station. The season of minimum run-off is 1923–24, with 305,000 acre-feet and the maximum is 1906–07, with 3,337,000 acre-feet, being 55.4 and 57.7 per cent, respectively, of the corresponding run-offs at Fairoaks.

TABLE 8. ESTIMATED SEASONAL RUN-OFF OF NORTH FORK OF AMERICAN RIVER AT AUBURN DAM SITE 1904-1927

Season (October 1 to September 30)	Estimated seasonal run-off		
	Unimpaired by upstream diversions, in acre-feet	Upstream diversions including 21,000 acre-feet for immediate expansion in irrigation development, in acre-feet	Available for power development, in acre-feet
1904-05	1,090,000	37,000	1,053,000
1905-06	2,846,000	37,000	2,809,000
1906-07	3,337,000	37,000	3,300,000
1907-08	856,000	37,000	819,000
1908-09	2,685,000	37,000	2,648,000
1909-10	2,118,000	37,000	2,081,000
1910-11	3,290,000	37,000	3,253,000
1911-12	753,000	37,000	716,000
1912-13	947,000	37,000	910,000
1913-14	2,527,000	37,000	2,490,000
1914-15	2,071,000	37,000	2,034,000
1915-16	2,423,000	37,000	2,386,000
1916-17	1,712,000	37,000	1,675,000
1917-18	853,000	37,000	816,000
1918-19	1,337,000	37,000	1,300,000
1919-20	827,000	37,000	790,000
1920-21	1,778,000	37,000	1,741,000
1921-22	1,854,000	37,000	1,817,000
1922-23	1,557,000	37,000	1,520,000
1923-24	305,000	37,000	268,000
1924-25	1,509,000	37,000	1,472,000
1925-26	763,000	37,000	726,000
1926-27	2,070,000	37,000	2,033,000
Average, 1904-27	1,718,000	37,000	1,681,000

Pilot Creek reservoir.

The Pilot Creek reservoir would be located on the North Fork of the American River between the Folsom and Auburn reservoirs. The dam site is in section 34, T. 12 N., R. 8 E., M. D. B. and M., about one-half mile below the mouth of Pilot Creek and 3 miles upstream from the Rattlesnake bridge. The dam would rise 110 feet above the low water elevation of 405 feet and would back water up to the power plant at the Auburn dam, elevation 515 feet. The site has been examined by Hyde Forbes. He reports, "Pilot Creek has eroded the southerly wall of the American River canyon where it crosses the massive amphibolite. But just below the junction of Pilot Creek with the river exists an excellent site for the structure proposed. The canyon walls rise at steep angles from a narrow stream bed. Stripping should be a minimum and firm rock should be found at shallow depth below stream bed."

The lands that would be flooded are relatively unimportant. The canal of the North Fork Ditch Company would be submerged for three miles, however, it would not be necessary to reconstruct it because an outlet could be provided in the dam for the purpose of passing water into the canal. With this arrangement, the present flow in the canal could be maintained and expensive maintenance charges now existent on the upper part of the canal would be eliminated.

The water supply available at the dam is that estimated for the Auburn reservoir less an average of 40,000 acre-feet per year for the prior right of the North Fork ditch. The increment to the flow originating on the intermediate area has been neglected in the estimates.

Coloma reservoir.

Two dam sites were surveyed for the Coloma reservoir on the South Fork of the American River. The first one considered is located in section 10, T. 11 N., R. 9 E., M. D. B. and M., at the mouth of Hastings Creek, about six miles downstream from the historic town of Coloma. In September, 1928, Hyde Forbes made a geological examination of this site. He reports that the site is underlain with a serpentine rock which he considers unsuitable for supporting the high gravity-concrete dam that had been proposed. He recommends the site be given no further consideration. Therefore, no estimates have been prepared for the Coloma reservoir with a dam at this site.

The second site, three miles downstream from the first one, was recommended by Mr. Forbes as being suitable, geological and topographically, for a high dam. The foundation rock at this point, he classifies as amphibolite, the same rock as that at the Pilot Creek dam site on the North Fork. Estimates of the Coloma reservoir presented in this report are based on a dam at this latter site, located in section 28, T. 11 N., R. 9 E., M. D. B. and M. At this point, the South Fork flows through a narrow gorge which it has cut through a massive amphibolite spur. The width of the gorge at the stream bed is 80 feet. The side walls rise at an average slope of 0.6 feet per foot of distance.

The dam would be 340 feet high, measured above low water elevation of 550 feet, with a crest length of 1300 feet. It would back water up the South Fork 15 miles, flooding 6565 acres of land to elevation 885 feet and impound 766,000 acre-feet of water.

The area within the reservoir site contains about 1550 acres that are cultivated or are suitable for cultivation, including about 250 acres of orchard. The remaining 5015 acres lie principally in gulches and on steep rocky slopes covered by small tree growth and are used for grazing. The more important improvements that would be flooded are the settlements at Coloma and Lotus and about 8 miles of the Mother Lode Highway between Auburn and Placerville. The county road between Shingle Springs and Lotus would also be flooded for about 2 miles.

These roads could be relocated without inconvenience to the traveling public. The Marshall monument, commemorating the first discovery of gold in Calfornia and situated on an eminence back of Coloma, would be more than 100 feet above the flow line of the reservoir. The estimated cost of lands and improvements flooded is $2,100,000, 20 per cent of the total cost of dam and reservoir.

The area and capacity of the reservoir for various heights of dam are set forth in the following table:

TABLE 9. CAPACITY OF COLOMA RESERVOIR

Height of dam, in feet (5 feet freeboard)	Water surface elevation of reservoir, in feet	Area of water surface, in acres	Capacity of reservoir, in acre-feet
55	600	125	2,000
75	620	205	5,000
95	640	315	11,000
115	660	465	20,000
135	680	710	32,000
155	700	1,150	50,000
175	720	1,670	80,000
195	740	2,295	120,000
215	760	2,955	172,000
235	780	3,590	236,000
255	800	4,150	312,000
275	820	4,670	402,000
295	840	5,235	500,000
315	860	5,825	613,000
335	880	6,420	733,000
340	885	6,565	766,000

There are 707.6 square miles of drainage area above the Coloma dam site. This is 37 per cent of the total area above Fairoaks gaging station of the United States Geological Survey. On this area originates 36 per cent of the total run-off of the American River. The run-off tributary to the Coloma reservoir has been estimated for the period 1904–1927 from records of stream measurements of the American River by the United States Geological Survey. As in estimating the run-off at the Auburn dam site, adjustments were made in the records of the stations on the three forks so as to conform to the measurements at Fairoaks after making allowances for diversions and run-off from the intermediate areas.

The estimated seasonal run-off from 1904 to 1927 is set forth in Table 10. Here is given the run-off unimpaired by upstream diversions and storage and also that available for power generation at the dam after deduction for upstream prior rights. The maximum run-off occurred in the season of 1906–07 with 2,101,000 acre-feet, the maximum in 1923–24 with 214,000 acre-feet. These are 198 and 20 per cent, respectively, of the average 1,063,000 acre-feet for the period of 1904–1927.

TABLE 10. ESTIMATED SEASONAL RUN-OFF OF SOUTH FORK OF AMERICAN RIVER AT COLOMA DAM SITE
1904-1927

Season (October 1 to September 30)	Estimated seasonal run-off		
	Unimpaired by upstream diversions, in acre-feet	Upstream diversions, in acre-feet	Available for power development, in acre-feet
1904-05	786,000	15,000	771,000
1905-06	1,718,000	15,000	1,703,000
1906-07	2,101,000	15,000	2,086,000
1907-08	570,000	15,000	555,000
1908-09	1,687,000	15,000	1,672,000
1909-10	1,331,000	15,000	1,316,000
1910-11	1,994,000	15,000	1,979,000
1911-12	482,000	15,000	467,000
1912-13	469,000	15,000	454,000
1913-14	1,305,000	15,000	1,290,000
1914-15	899,000	15,000	884,000
1915-16	1,353,000	15,000	1,338,000
1916-17	1,091,000	15,000	1,076,000
1917-18	584,000	15,000	569,000
1918-19	764,000	15,000	749,000
1919-20	568,000	15,000	553,000
1920-21	1,245,000	15,000	1,230,000
1921-22	1,269,000	15,000	1,254,000
1922-23	1,012,000	15,000	1,027,000
1923-24	214,000	15,000	199,000
1924-25	1,080,000	15,000	1,065,000
1925-26	535,000	15,000	520,000
1926-27	1,367,000	15,000	1,352,000
Average, 1904-27	1,063,000	15,000	1,048,000

Webber Creek reservoir.

The dam for the Webber Creek reservoir would be located in section 30, T. 11 N., R. 9 E., M. D. B. and M., on the South Fork of the American River about 1 mile downstream from its confluence with Webber Creek. The dam would be 90 feet high above low water elevation 460 feet and would back water up to the Coloma dam power plant at elevation 550 feet. The capacity of the reservoir has not been calculated but it would be relatively small. The purpose of the dam would be to create a power head of 115 feet between the Coloma and Folsom reservoirs.

The site has been examined by Hyde Forbes, who found it to be suitable geologically for a concrete dam 150 feet high. The foundation rock is of igneous origin, hard and durable.

About 200 acres of land of relatively low value and no improvements of importance would be flooded by the reservoir. The Natomas Canal diverts from the South Fork about 1½ miles below the dam and therefore would not be affected. The Monte Mine, an inactive property, is above the flow line of the reservoir.

The water supply available for power generation at the dam would be the release and spill from the Coloma reservoir augmented by the run-off from Webber Creek. In the power estimates, however, the run-off from Webber Creek has been neglected. It would be relatively small in amount in the critical months and in months of large run-off, there probably would be a surplus passing the Coloma dam, which could not be utilized without increasing the capacity of the power plant. Only a detailed study could determine whether this would be justified. This has not been made.

CHAPTER IV

ELECTRIC POWER OUTPUT FROM CONSOLIDATED DEVELOPMENT

Location and mode of operation of power plants.

Power plants for the generation of electric power would be located below the dams and would operate under the head created by the reservoirs. The head would be variable in the case of Folsom, Auburn and Coloma and constant for Pilot Creek and Webber Creek reservoirs.

Estimates of power output have been made for various modes of reservoir operation and power plant capacities. These have been prepared with the reservoirs operated primarily for power generation and for irrigation use. The effect on the power output and irrigation use of utilizing space in the reservoirs for flood and salinity control has also been estimated and is set forth herein.

The power output has been calculated for two methods of water release from the reservoir operating primarily for power. One method of release would develop maximum continuous or primary power throughout the year, including extremely dry seasons such as 1923–24, by varying the water release with the head on the plant, and also additional intermittent seasonal or secondary power up to the capacity of the economic power installation when water would be available in excess of that required for the generation of the primary power. This method has been employed in estimating the power yield of the various units of the "Coordinated Plan," * when operated primarily for power purposes and is included herein to allow a comparison with those units. The second method, proposed by the American River Hydro-electric Company would release water through the turbines at a constant rate when available, developing a larger amount of power but much more variable than in the first instance. In this method, the reservoirs would be drawn to low levels at the end of each season and the amount of power generated would have a greater variation from season to season and from month to month in the season and, therefore, would be less dependable than with the method of water release developing maximum primary power.

Methods employed in estimating power output.

The power output from the several power plants was estimated, month by month, from 1904 to 1927, the period of stream measurement at the Fairoaks gaging station, taking into account the draft from the reservoir, the head on and the efficiency of the power plant. A constant tailrace elevation was assumed for each particular plant. The overall plant efficiency was taken at 75 per cent and was assumed constant for all heads. This figure allows for all losses between reservoir and tailrace, including entrance, penstock and draft tube losses.

In the method of water release, developing maximum primary power, the primary power output was maintained, month by month, by varying the release through the turbines with the changing level of the

* See Bulletin No. 12, "Summary Report on Water Resources of California and a Coordinated Plan for Their Development," Division of Engineering and Irrigation, State of California, Department of Public Works.

reservoir so as to meet the demand for each particular month in accord with the schedule of state-wide demand for power, given in Table 11. Power in addition to the primary power was included in the computations up to the capacity of the generators when water was available, taking into account the load factor on which the plant would be operated. Plant load factor as used in this report is the ratio of the average power output for a month in kilowatts to the rated capacity of the plant in kilowatts.

TABLE 11. MONTHLY DISTRIBUTION OF ELECTRIC POWER DEMAND STATE-WIDE AVERAGE

Month	Electric power demand in per cent of annual total	Month	Electric power demand in per cent of annual total
January	7.3	August	9.5
February	6.9	September	8.7
March	7.8	October	8.5
April	7.9	November	8.0
May	8.8	December	8.2
June	9.0		
July	9.4	Total	100.0

The average maximum daily output capacity of a plant was taken the same for each method of water release but the installed capacity varied. For the method of release, developing maximum primary power, all power installations were based on a 75 per cent plant load factor, and for the method proposed by the American River Hydro-electric Company on a 60 per cent load factor, except for the installation at the Folsom dam, which was based on the plant operating on a 100 per cent load factor.

In the computations an allowance was made for evaporation and precipitation on the surface of the reservoirs. The net evaporation was estimated at 3.5 feet depth per season, distributed as follows:

TABLE 12. NET EVAPORATION FROM RESERVOIR SURFACE

Month	Net evaporation	
	Depth in feet	In per cent of seasonal total
January	0	0
February	0	0
March	0	0
April	0.32	9.2
May	0.44	12.6
June	0.52	15.0
July	0.62	17.8
August	0.58	16.6
September	0.45	12.7
October	0.34	9.6
November	0.23	6.5
December	0	0
Total	3.50	100.0

Power output from the Folsom plant.

A power plant would be located below the Folsom dam, near the head of the Folsom Canal, which supplies the Folsom City plant of the Pacific Gas and Electric Company, located 9000 feet downstream from the proposed plant at the Folsom dam. Water would be delivered to the proposed plant through a tunnel under the left abutment of the dam.

Two alternate power plant layouts have been studied. They differ only in the point of discharge of the tail water from the plant. The first layout, proposed by the American River Hydro-electric Company, would consist of two generating units, one discharging its tail water directly into the Folsom Canal, with the second unit discharging into the American River below the present Folsom Prison dam, which serves as a diversion dam for the Folsom Canal. The tailrace elevation of the first unit would be 207.0 feet, and that of the second 162.0 feet. With the reservoir full (water surface elevation 390 feet) this would give maximum static heads of 183 and 228 feet for the first and second units, respectively. In the power studies, the volumes of water released through each unit varied with the natural stream flow and amount of release from storage. The release through the first unit was the natural stream flow up to 1000 second-feet, the capacity of the Folsom Canal, supplemented with stored water when available during periods of low stream flow. The release through the second unit was limited by the requirements of the first unit and the water capacity of the second unit.

In the second layout, all the water released through the turbines would be discharged into the Folsom Canal. The upper 1600 feet of canal below the plant would be enlarged and deepened to make available an additional 7 feet of drop now being utilized at the Folsom State Prison power plant, which would be abandoned. The maximum head on the plant would then be 190 feet, 7 feet greater than that of the first unit of the first layout. All water discharged through this plant could be carried to and through the Folsom City plant of the Pacific Gas and Electric Company by enlarging the Folsom Canal and reconstructing the present Folsom City plant. By this arrangement a considerable increase in total power output would be obtained in the power development. This, however, would result in the released water being discharged in the river at an elevation too low for gravity irrigation of a large part of the valley agricultural lands dependent on this source of supply and would be of particular value only during the period preceding the need of the water for irrigation.

The installed capacity of the Folsom plant would vary with the mode of operation of the reservoir and with the stage of development of the project. A larger installed power plant capacity would be justified if Auburn or Coloma reservoirs were constructed due to the regulatory effect they would have on the stream flow for this plant. The installed capacity would vary from 35,000 k.v.a. P.F.=0.80, and a load factor of 1.00 with Folsom reservoir as a first installation in the development, to 54,000 k.v.a. P.F.=0.80 and a load factor of 0.75 for the complete development with Auburn and Coloma reservoirs constructed and operated in conjunction with Folsom.

In Tables 13, 14, 15, and 16 that follow, are set forth the power output and power characteristics of the Folsom plant for different methods of water release, plant layouts and stages of development.

Table 13 gives the total yearly power outputs in kilowatt hours for the period 1905–1927, for the following stages of development: (1) without either Auburn or Coloma constructed; (2) with Auburn constructed and operated to develop maximum primary power and Coloma not constructed; (3) with both Auburn and Coloma reservoirs constructed and operated to develop maximum primary power. All the tail water would be discharged into the Folsom Canal at tailrace elevation of 200 feet. The total primary power output would be increased from 85,900,000 kilowatt hours per year without Auburn and Coloma reservoirs constructed to 172,600,000 kilowatt hours with both Auburn and Coloma constructed and correspondingly the average total annual output would be increased from 153,700,000 kilowatt hours to 217,400,000 kilowatt hours.

Table 14 sets forth similar data for the schedule of water release proposed by the American River Hydro-electric Company with the plant layout that would discharge part of the tail-water into the Folsom Canal at elevation 207 feet and the remainder into the American River at elevation 162 feet.

In Tables 15 and 16, characteristics of the power output are shown for the two methods of water release from the reservoirs operated primarily for power for various stages of development. The monthly output is tabulated for years of maximum and minimum output expressed in millions of kilowatt hours and in per cent of annual total, and also for the minimum year in per cent of annual total of the maximum year. These tables show that there is a wider variation in the values for the maximum and minimum years with the schedule of water release proposed by the American River Hydro-electric Company than with that developing maximum primary power. The output with the latter method of release conforms more nearly to the state-wide average demand for power which is given at the left of the tables.

TABLE 13. POWER OUTPUT OF FOLSOM PLANT

Folsom reservoir operated in accord with schedule of water release to develop maximum primary power

Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet

Tailrace elevation of power plant, 200 feet

Year	Power output, in kilowatt hours		
	Auburn and Coloma reservoirs not constructed. Installed capacity of power plant 43,000 k.v.a. P.F.=0.80 L.F.=0.75 Annual primary power output 85,900,000 kilowatt hours	Auburn reservoir constructed and operated to develop maximum primary power. Coloma reservoir not constructed. Installed capacity of power plant 54,000 k.v.a. P.F.=0.80 L.F=0.75 Annual primary power output 126,200,000 kilowatt hours	Auburn and Coloma reservoirs constructed and operated to develop maximum primary power. Installed capacity of power plant 54,000 k.v.a. P.F.=0.80 L.F.=0.75 Annual primary power output 172,600,000 kilowatt hours
1905	150,000,000	196,900,000	212,700,000
1906	179,900,000	229,400,000	246,900,000
1907	192,800,000	241,100,000	254,100,000
1908	145,600,000	183,000,000	198,900,000
1909	185,200,000	233,100,000	246,800,000
1910	156,000,000	195,600,000	220,800,000
1911	162,600,000	210,200,000	235,400,000
1912	125,300,000	158,800,000	190,400,000
1913	136,400,000	174,100,000	208,000,000
1914	165,700,000	210,400,000	232,800,000
1915	164,500,000	206,000,000	232,100,000
1916	178,200,000	223,000,000	239,700,000
1917	158,200,000	197,800,000	219,700,000
1918	133,500,000	168,100,000	193,300,000
1919	134,000,000	175,500,000	201,900,000
1920	138,200,000	185,300,000	199,500,000
1921	163,300,000	207,700,000	225,800,000
1922	166,500,000	208,600,000	218,600,000
1923	156,000,000	198,800,000	221,200,000
1924	87,700,000	126,200,000	172,600,000
1925	140,800,000	183,700,000	198,600,000
1926	145,200,000	165,200,000	199,100,000
1927*	131,400,000	165,800,000	178,500,000
Average	153,700,000	195,300,000	217,400,000

*Partial year, January 1 to October 1

TABLE 14. POWER OUTPUT OF FOLSOM PLANT

Folsom reservoir operated in accord with schedule of water release proposed by American River Hydro-electric Company

Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet

Tailrace elevations of power plant, 207 and 162 feet

Year	Power output, in kilowatt hours*		
	Auburn and Coloma reservoirs not constructed. Installed capacity of power plant, 35,000 k.v.a. P.F.=0.80 L.F.=1.00	Auburn reservoir constructed and operated in accord with schedule of water release proposed by American River Hydro-Electric Company. Coloma reservoir not constructed. Installed capacity of power plant, 45,000 k.v.a. P F.=0 80 L.F.=1.00	Auburn and Coloma reservoirs constructed and operated in accord with schedule of water releaso proposed by American River Hydro-Electric Company. Installed capacity of power plant, 45,000 k.v.a P.F.=0.80 L.F.=1.00
1905	152,000,000	243,500,000	251,700,000
1906	193,200,000	278,400,000	279,600,000
1907	209,700,000	283,700,000	286,800,000
1908	152,900,000	239,600,000	278,500,000
1909	202,700,000	281,100,000	286,000,000
1910	167,800,000	268,900,000	286,200,000
1911	175,700,000	275,400,000	290,100,000
1912	122,500,000	172,200,000	248,000,000
1913	123,500,000	183,200,000	194,800,000
1914	180,900,000	276,700,000	286,300,000
1915	166,200,000	266,500,000	288,500,000
1916	186,100,000	277,400,000	288,600,000
1917	155,200,000	270,000,000	286,700,000
1918	130,400,000	220,400,000	247,900,000
1919	132,200,000	219,900,000	259,900,000
1920	141,600,000	222,700,000	211,600,000
1921	181,700,000	274,300,000	275,400,000
1922	180,600,000	268,400,000	285,400,000
1923	180,200,000	272,800,000	286,900,000
1924	41,300,000	62,100,000	152,300,000
1925	163,700,000	250,600,000	254,700,000
1926	143,100,000	210,700,000	246,300,000
1927**	161,800,000	207,400,000	204,100,000
Average	160,200,000	242,900,000	262,700,000

*Estimate of power output based on measured stream flow at Fairoaks gaging station.
**Partial year, January 1 to October 1.

TABLE 15. CHARACTERISTICS OF POWER OUTPUT OF FOLSOM PLANT

Power output with water release from Folsom reservoir to develop maximum primary power

1905-1927

Height of dam, 190 feet | Capacity of reservoir, 355,000 acre-feet | Tailrace elevation of power plant, 200 feet

Month	State-wide average monthly demand for power in per cent of annual total	Without Auburn and Coloma Reservoirs Constructed. Installed capacity of power plant, 43,000 k. v. a. P.F.=0.80 L.F.=0.75. Average annual power output, 153,700,000 kilowatt hours					With Auburn Reservoir Constructed and Operated to Develop Maximum Primary Power. Coloma Reservoir not Constructed. Installed capacity of power plant, 54,000 k. v. a. P.F.=0.80 L.F.=0.75. Average annual power output, 195,300,000 kilowatt hours					With Auburn and Coloma Reservoirs Constructed and Operated to Develop Maximum Primary Power. Installed capacity of power plant, 54,000 k. v. a. P.F.=0.80 L.F.=0.75. Average annual power output, 217,400,000 kilowatt hours				
		Maximum year, 1907		Minimum year, 1924			Maximum year, 1907		Minimum year, 1924			Maximum year, 1907		Minimum year, 1924		
		Millions of kilowatt hours	Per cent of annual total	Millions of kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year	Millions of kilowatt hours	Per cent of annual total	Millions of kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year	Millions of kilowatt hours	Per cent of annual total	Millions of kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	18.0	9.35	6.3	7.2	3.3	22.4	9.3	9.2	7.3	3.8	22.4	8.8	12.6	7.3	5.0
February	6.9	16.2	8.4	5.9	6.7	3.1	20.3	8.4	8.7	6.9	3.6	20.3	8.1	11.9	6.9	4.7
March	7.8	18.0	9.35	6.7	7.6	3.5	22.4	9.3	9.8	7.8	4.1	22.4	8.8	13.5	7.8	5.3
April	7.9	17.4	9.0	6.8	7.8	3.5	21.7	9.0	10.0	7.9	4.1	21.7	8.5	13.6	7.9	5.3
May	8.8	18.0	9.35	9.3	10.6	4.8	22.4	9.3	11.1	8.8	4.6	22.4	8.8	15.2	8.8	6.0
June	9.0	17.4	9.0	7.7	8.8	4.0	21.7	9.0	11.4	9.0	4.7	21.7	8.5	15.5	9.0	6.1
July	9.4	18.0	9.35	8.1	9.2	4.2	22.4	9.3	11.9	9.4	4.9	22.4	8.8	16.2	9.4	6.4
August	9.5	18.0	9.35	8.2	9.3	4.2	22.4	9.3	12.0	9.5	5.0	22.4	8.8	16.4	9.5	6.4
September	8.7	12.6	6.5	7.5	8.6	3.9	15.5	6.4	11.0	8.7	4.6	20.6	8.1	15.0	8.7	5.9
October	8.5	10.0	5.2	7.3	8.3	3.8	13.4	5.6	10.7	8.5	4.4	17.5	6.9	14.7	8.5	5.8
November	8.0	11.2	5.8	6.9	7.9	3.6	14.5	6.0	10.1	8.0	4.2	17.9	7.1	13.8	8.0	5.4
December	8.2	18.0	9.35	7.0	8.0	3.6	22.0	9.1	10.3	8.2	4.3	22.4	8.8	14.2	8.2	5.6
Totals	100.0	192.8	100.0	87.7	100.0	45.5	241.1	100.0	126.2	100.0	52.3	254.1	100.0	172.6	100.0	67.9

TABLE 16. CHARACTERISTICS OF POWER OUTPUT OF FOLSOM PLANT

Power output with water release from Folsom reservoir operated in accord with schedule of water release proposed by American River Hydro-electric Company
1905-1927

Height of dam, 190 feet — Capacity of reservoir, 355,000 acre-feet — Tailrace elevations of power plant, 207 and 162 feet

Month	State-wide average monthly demand for power in per cent of annual total	Without Auburn and Coloma Reservoirs Constructed. Installed capacity of power plant, 35,000 k. v. a. P.F.=0.80 L.F.=1.00. Average annual power output, 160,200,000 kilowatt hours					With Auburn Reservoir Constructed and Operated in Accord with Schedule Proposed by American River Hydro-electric Company. Coloma Reservoir Not Constructed. Installed capacity of power plant, 45,000 k. v. a. P.F.=0.80 L.F.=1.00. Average annual power output, 242,900,000 kilowatt hours					With Auburn and Coloma Reservoirs Constructed and Operated in Accord With Schedule of Water Release Proposed by American River Hydro-electric Company. Installed capacity of power plant, 45,000 k. v. a. P.F.=0.80 L.F.=1.00. Average annual power output, 262,700,000 kilowatt hours				
		Maximum year, 1907		Minimum year, 1924			Maximum year, 1907		Minimum year, 1924			Maximum year, 1911		Minimum year, 1924		
		Millions of kilowatt hours	Per cent of annual total	Millions of kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year	Millions of kilowatt hours	Per cent of annual total	Millions of kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year	Millions of kilowatt hours	Per cent of annual total	Millions of kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	17.0	8.1	2.1	5.1	1.0	24.0	8.4	5.3	8.5	1.9	24.9	8.6	22.7	14.9	7.8
February	6.9	17.5	8.3	8.6	20.6	4.1	22.4	7.9	12.2	19.7	4.3	22.4	7.7	20.0	13.1	6.9
March	7.8	19.4	9.3	4.2	10.4	2.0	24.9	8.8	5.2	8.4	1.8	24.9	8.6	19.7	12.9	6.8
April	7.9	18.8	9.0	8.0	19.4	3.8	24.0	8.45	12.1	19.5	4.3	24.0	8.3	17.4	11.4	6.0
May	8.8	19.4	9.3	7.7	18.7	3.7	24.9	8.8	8.1	13.0	2.9	24.9	8.6	17.6	11.6	6.1
June	9.0	18.8	9.0	0.7	1.7	0.3	24.0	8.45	0.4	0.6	0.1	24.0	8.3	17.1	11.2	5.9
July	9.4	19.4	9.3	0.1	0.2	0.1	24.9	8.8	0.4	0.6	0.1	24.9	8.6	17.6	11.6	6.1
August	9.5	19.2	9.1	0.1	0.2	0.1	24.6	8.7	0.7	1.1	0.2	24.9	8.6	3.0	2.0	1.0
September	8.7	17.6	8.4	0.1	0.2	0.1	23.3	8.2	1.0	1.6	0.4	23.8	8.2	1.1	0.7	0.4
October	8.5	16.6	7.9	0.8	1.9	0.4	23.2	8.2	2.1	3.4	0.8	24.2	8.3	2.3	1.5	0.8
November	8.0	13.9	6.6	3.7	9.0	1.7	21.6	7.6	5.5	8.9	1.9	23.3	8.0	5.5	3.6	1.9
December	8.2	12.1	5.7	5.2	12.6	2.5	21.9	7.7	9.1	14.7	3.2	23.9	8.2	8.3	5.5	2.8
Totals	100.0	209.7	100.0	41.3	100.0	19.8	283.7	100.0	62.1	100.0	21.9	290.1	100.0	152.3	100.0	52.5

Power output from Auburn and Pilot Creek plants.

Power would be generated in power plants located below the Auburn and Pilot Creek dams on the North Fork of the American River. Water would be conveyed to the turbines of the plants through tunnels similar to the layout at the Folsom dam. The Auburn plant would operate under the fluctuating head created by the reservoir in a like manner to that of the Folsom plant. The head would vary from a maximum of 385 feet with a full reservoir (water surface elevation 900 feet) to a minimum of 165 feet. A constant tailrace elevation of 515 feet has been assumed for the estimates. The Pilot Creek plant would operate under practically a constant head as it is contemplated that no water would be drawn from storage in the reservoir since the main purpose of the dam would be to develop power head between the Folsom and Auburn reservoirs. The plant would utilize the water released from the Auburn reservoir without re-regulation; however, some daily regulation could be obtained if desired. The normal static head on the plant, 110 feet, would be the difference in elevation between 515 feet, the maximum water surface of the reservoir and the tailrace elevation of 405 feet, 15 feet above the maximum water surface elevation (390 feet) of the Folsom reservoir.

Tables 17, 18, 19 and 20 give information on the estimated power output and on the power characteristics of the two power plants with the Auburn reservoir operated in accord with the same two methods of water release used in the estimates for the Folsom reservoir, for the period 1905–1927. In Table 17 are set forth the yearly power outputs of the Auburn plant with the Auburn reservoir operated by the two methods of water release. The characteristics of the power output from this plant for both methods of water release are compared in Table 18 for years of maximum and minimum power output. Similar data are given in Tables 19 and 20 for the Pilot Creek plant.

TABLE 17. POWER OUTPUT OF AUBURN PLANT

Auburn reservoir operated in accord with two schedules of water release

Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet

Tailrace elevation of power plant, 515 feet

Year	Power output, in kilowatt hours	
	Water release to develop maximum primary power. Installed capacity of power plant 66,000 k.v.a. P.F.=0.80 L.F.=0.75 Annual primary power output 142,000,000 kilowatt hours	Water release in accord with schedule proposed by American River Hydro-electric Company. Installed capacity of power plant 82,000 k.v.a. P.F.=0.80 L.F.=0.60
1905	217,700,000	231,300,000
1906	260,800,000	288,800,000
1907	290,600,000	301,400,000
1908	187,800,000	216,400,000
1909	283,700,000	304,700,000
1910	229,900,000	285,000,000
1911	253,400,000	295,200,000
1912	185,400,000	163,900,000
1913	198,500,000	200,100,000
1914	245,300,000	293,400,000
1915	238,000,000	274,100,000
1916	263,700,000	292,700,000
1917	223,400,000	276,900,000
1918	177,600,000	195,200,000
1919	188,400,000	228,000,000
1920	201,000,000	206,800,000
1921	239,900,000	281,700,000
1922	223,800,000	258,300,000
1923	238,800,000	284,800,000
1924	142,000,000	56,300,000
1925	186,100,000	259,100,000
1926	188,000,000	180,100,000
1927*	183,500,000	217,500,000
Average	221,900,000	245,800,000

*Partial year, January 1 to October 1.

TABLE 18. CHARACTERISTICS OF POWER OUTPUT OF AUBURN PLANT WITH TWO SCHEDULES OF WATER RELEASE FROM AUBURN RESERVOIR
1905-1927

Height of dam, 390 feet — Capacity of reservoir, 598,000 acre-feet — Tailrace elevation of power plant, 515 feet

Month	State-wide average monthly demand for power in per cent of annual total	Power output with water release to develop maximum primary power. Installed capacity of power plant, 66,000 k.v.a. P.F.=0.80 L.F.=0.75. Average annual power output, 221,900,000 kilowatt hours					Power output with water release in accord with schedule proposed by American River Hydro-electric Company. Installed capacity of power plant, 82,000 k.v.a. P.F.=0.80 L.F.=0.60. Average annual power output, 245,800,000 kilowatt hours				
		Maximum year, 1907		Minimum year, 1924			Maximum year, 1909		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year	Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	27,300,000	9.4	10,300,000	7.3	3.5	21,700,000	7.1	5,600,000	9.9	1.8
February	6.9	24,600,000	8.5	9,800,000	6.9	3.4	24,600,000	8.1	11,100,000	19.7	3.7
March	7.8	27,300,000	9.4	11,000,000	7.8	3.8	27,300,000	8.9	5,200,000	9.2	1.7
April	7.9	26,400,000	9.1	11,200,000	7.9	3.9	26,400,000	8.7	11,200,000	19.9	3.7
May	8.8	27,300,000	9.4	12,500,000	8.8	4.3	27,300,000	8.9	8,100,000	14.4	2.7
June	9.0	26,400,000	9.1	12,800,000	9.0	4.4	26,400,000	8.7	400,000	0.7	0.1
July	9.4	27,300,000	9.4	13,400,000	9.4	4.6	27,200,000	8.9	700,000	1.2	0.2
August	9.5	27,300,000	9.4	13,500,000	9.5	4.6	26,900,000	8.9	200,000	0.4	0.1
September	8.7	18,300,000	6.2	12,400,000	8.7	4.3	24,400,000	8.0	400,000	0.7	0.1
October	8.5	16,200,000	5.6	12,100,000	8.5	4.2	23,600,000	7.8	2,000,000	3.6	0.7
November	8.0	16,900,000	5.8	11,300,000	8.0	3.9	23,000,000	7.5	4,600,000	8.2	1.5
December	8.2	25,300,000	8.7	11,700,000	8.2	4.0	25,900,000	8.5	6,800,000	12.1	2.2
Totals	100.0	290,600,000	100.0	142,000,000	100.0	48.9	304,700,000	100.0	56,300,000	100.0	18.5

TABLE 19. POWER OUTPUT OF PILOT CREEK PLANT WITH AUBURN RESERVOIR OPERATED IN ACCORD WITH TWO SCHEDULES OF WATER RELEASE

Height of dam, 110 feet

Tailrace elevation of power plant, 405 feet

Year	Power output, in kilowatt hours	
	Water release from Auburn reservoir to develop maximum primary power. Installed capacity of power plant, 19,000 k.v.a. P.F.=0.80 L.F.=0.75 Annual primary power output, 37,600,000 kilowatt hours.	Water release from Auburn reservoir in accord with schedule proposed by American River Hydro-electric Company. Installed capacity of power plant, 23,000 k.v.a. P.F.=0.80 L.F.=0 60
1905	61,000,000	80,300,000
1906	73,500,000	89,800,000
1907	82,800,000	90,100,000
1908	52,900,000	73,700,000
1909	80,100,000	90,100,000
1910	65,200,000	88,200,000
1911	72,100,000	90,400,000
1912	55,400,000	66,000,000
1913	57,700,000	74,300,000
1914	69,500 000	96,100,000
1915	68,100,000	87,800,000
1916	74,500,000	90,100,000
1917	63,800,000	89,500,000
1918	50,700,000	71,600,000
1919	53,800,000	75,000,000
1920	57,300,000	75,900,000
1921	68,400,000	89,800,000
1922	63,500,000	85,800,000
1923	67,300,000	89,300,000
1924	49,900,000	23,800,000
1925	58,000,000	83,300,000
1926	53,500,000	69,400,000
1927*	56,200,000	67,500,000
Average	63,900,000	80,500,000

*Partial year, January 1 to October 1.

TABLE 20. CHARACTERISTICS OF POWER OUTPUT OF PILOT CREEK PLANT WITH AUBURN RESERVOIR OPERATED IN ACCORD WITH TWO SCHEDULES OF WATER RELEASE

1905-1927

Height of dam, 110 feet — Tailrace elevation of power plant, 405 feet

Month	State-wide average monthly demand for power in per cent of annual total	Power output with water release from Auburn reservoir to develop maximum primary power. Installed capacity of power plant, 19,000 k.v.a. P.F.=0.80 L.F.=0.75. Average annual power output, 63,900,000 kilowatt hours					Power output with water release from Auburn reservoir in accord with schedule proposed by American River Hydro-electric Company. Installed capacity of power plant, 23,000 k.v.a. P.F.=0.80 L.F.=0.60. Average annual power output, 79,100,000 kilowatt hours				
		Maximum year, 1907		Minimum year, 1924			Maximum year, 1911		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year	Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	7,400,000	8.9	3,100,000	6.2	3.7	7,800,000	8.6	2,100,000	8.8	2.3
February	6.9	7,100,000	8.6	2,900,000	5.8	3.5	7,100,000	7.9	5,000,000	21.0	5.5
March	7.8	7,800,000	9.4	3,300,000	6.6	4.0	7,800,000	8.6	2,200,000	9.3	2.4
April	7.9	7,600,000	9.2	3,400,000	6.8	4.1	7,500,000	8.3	5,200,000	21.9	5.8
May	8.8	7,800,000	9.4	3,700,000	7.4	4.5	7,800,000	8.6	3,600,000	15.1	4.0
June	9.0	7,600,000	9.2	3,900,000	7.8	4.7	7,500,000	8.3	0	0	0
July	9.4	7,800,000	9.4	4,300,000	8.6	5.2	7,800,000	8.6	100,000	0.4	0.1
August	9.5	7,600,000	9.2	4,700,000	9.5	5.7	7,500,000	8.3	0	0	0
September	8.7	5,100,000	6.2	4,600,000	9.2	5.6	7,300,000	8.1	0	0	0
October	8.5	4,600,000	5.6	5,000,000	10.0	6.0	7,500,000	8.3	700,000	2.9	0.8
November	8.0	5,000,000	6.0	5,100,000	10.2	6.2	7,300,000	8.1	1,900,000	8.0	2.1
December	8.2	7,400,000	8.9	5,900,000	11.9	7.1	7,500,000	8.3	3,000,000	12.6	3.3
Totals	100.0	82,800,000	100.0	49,900,000	100.0	60.3	90,400,000	100.0	23,800,000	100.0	26.3

Power output from Coloma and Webber Creek plants.

The power plant layout at the Coloma and Webber Creek dams would be similar to those at Auburn and Folsom dams. Water would be delivered through tunnels to the turbines in the power plants, located below the dams.

The power house of the Coloma reservoir would be located on the right bank of the South Fork, about 2000 feet below the dam, and would operate under a maximum head of 330 feet and a minimum head of 165 feet. The tailrace of the plant has been taken at 555 feet in estimating the power output. The Webber Creek power house as proposed by the American River Hydro-electric Company would be located about 4000 feet downstream from the dam with a diversion tunnel about 3000 feet long. The plant would operate under a constant head of 115 feet.

The power output and power characteristics of the two plants are shown in the Tables 21, 22, 23 and 24 for the period of 1905–27. Data are given in Tables 21 and 22 for the Coloma plant and in Tables 23 and 24 for the Webber Creek plant.

TABLE 21. POWER OUTPUT OF COLOMA PLANT

Coloma reservoir operated in accord with two schedules of water release

Height of dam, 340 feet — Tailrace elevation of power plant, 555 feet
Capacity of reservoir, 766,000 acre-feet

Year	Power output in kilowatt hours	
	Water release to develop maximum primary power. Installed capacity of power plant, 30,000 k.v.a. P.F.=0.80 L.F.=0.75 Annual primary power output 127,900,000 kilowatt hours.	Water release in accord with schedule proposed by American River Hydro-electric Company. Installed capacity of power plant 37,000 k.v.a. P.F.=0.80 L.F.=0.60
1905	134,900,000	138,600,000
1906	144,700,000	143,200,000
1907	147,200,000	144,900,000
1908	132,500,000	141,200,000
1909	147,200,000	145,000,000
1910	139,300,000	142,700,000
1911	143,300,000	143,700,000
1912	129,500,000	130,200,000
1913	127,900,000	85,700,000
1914	136,900,000	132,100,000
1915	136,600,000	140,100,000
1916	147,600,000	144,000,000
1917	137,600,000	142,400,000
1918	129,700,000	137,400,000
1919	131,100,000	133,200,000
1920	129,900,000	126,100,000
1921	141,900,000	141,800,000
1922	139,000,000	142,400,000
1923	139,900,000	143,400,000
1924	127,900,000	81,100,000
1925	128,500,000	123,200,000
1926	129,100,000	133,500,000
1927*	108,300,000	106,200,000
Average	136,700,000	133,700,000

*Partial year, January 1 to October 1.

TABLE 22. CHARACTERISTICS OF POWER OUTPUT OF COLOMA PLANT WITH TWO SCHEDULES OF WATER RELEASE FROM COLOMA RESERVOIR
1905-1927

Height of dam, 340 feet — Capacity of reservoir, 766,000 acre-feet — Tailrace elevation of power plant, 555 feet

Month	State-wide average monthly demand for power in per cent of annual total	Power output with water release to develop maximum primary power. Installed capacity of power plant, 30,000 k.v.a. P.F.=0.80 L.F.=0.75. Average annual power output, 136,700,000 kilowatt hours					Power output with water release in accord with schedule proposed by American River Hydro-Electric Company. Installed capacity of power plant, 37,000 k.v.a. P.F.=0.80 L.F.=0.60. Average annual power output, 133,700,000 kilowatt hours				
		Maximum year,* 1907		Minimum year,** 1924			Maximum year, 1909		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total maximum year	Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	12,500,000	8.5	9,300,000	7.3	6.3	11,800,000	8.1	11,100,000	13.7	7.7
February	6.9	11,300,000	7.7	8,800,000	6.9	6.0	11,300,000	7.8	10,200,000	12.6	7.0
March	7.8	12,500,000	8.5	10,000,000	7.8	6.8	12,500,000	8.6	10,800,000	13.3	7.4
April	7.9	12,100,000	8.2	10,100,000	7.9	6.9	12,100,000	8.4	10,200,000	12.6	7.0
May	8.8	12,500,000	8.5	11,300,000	8.8	7.7	12,500,000	8.6	10,200,000	12.6	7.0
June	9.0	12,100,000	8.2	11,500,000	9.0	7.8	12,100,000	8.4	9,000,000	11.1	6.2
July	9.4	12,500,000	8.5	12,000,000	9.4	8.2	12,500,000	8.6	7,700,000	9.5	5.3
August	9.5	12,500,000	8.5	12,200,000	9.5	8.3	12,400,000	8.5	3,400,000	4.2	2.3
September	8.7	12,100,000	8.2	11,100,000	8.7	7.5	11,800,000	8.1	800,000	1.0	0.6
October	8.5	12,500,000	8.5	10,900,000	8.5	7.4	12,000,000	8.3	800,000	1.0	0.6
November	8.0	12,100,000	8.2	10,200,000	8.0	6.9	11,700,000	8.1	2,700,000	3.3	1.9
December	8.2	12,500,000	8.5	10,500,000	8.2	7.1	12,300,000	8.5	4,200,000	5.1	2.9
Totals	100.0	147,200,000	100.0	127,900,000	100.0	86.9	145,000,000	100.0	81,100,000	100.0	55.9

*Other year giving maximum power output, 1909.
**Other year giving minimum power output, 1915.

TABLE 23. POWER OUTPUT OF WEBBER CREEK PLANT

Coloma reservoir operated in accord with two schedules of water release

Height of dam, 90 feet

Tailrace elevation of power plant, 435 feet

Year	Power output in kilowatt hours	
	Water release to develop maximum primary power. Installed capacity of power plant, 10,000 k.v.a. P.F.=0.80 L.F.=0.75	Water release in accord with schedule proposed by American River Hydro-electric Company. Installed capacity of power plant 13,000 k.v.a. P.F.=0.80 L.F.=0.60
1905	48,600,000	51,200,000
1906	50,500,000	51,200,000
1907	51,200,000	51,200,000
1908	47,700,000	51,300,000
1909	51,200,000	51,200,000
1910	49,900,000	51,200,000
1911	50,500,000	51,200,000
1912	49,800,000	51,300,000
1913	50,600,000	46,400,000
1914	49,700,000	51,200,000
1915	49,200,000	51,200,000
1916	51,300,000	51,300,000
1917	49,000,000	51,200,000
1918	47,800,000	51,200,000
1919	48,300,000	51,200,000
1920	49,200,009	51,300,000
1921	50,100,000	51,200,000
1922	49,600,000	51,200,000
1923	49,700,000	51,200,000
1924	49,300,000	38,100,000
1925	49,800,000	49,600,000
1926	47,900,000	51,200,000
1927*	38,000,000	38,300,000
Average	49,600,000	50,400,000

*Partial year, January 1 to October 1.

TABLE 24. CHARACTERISTICS OF POWER OUTPUT OF WEBBER CREEK PLANT WITH TWO SCHEDULES OF WATER RELEASE FROM COLOMA RESERVOIR 1905-1927

Height of dam, 90 feet

Tailrace elevation of power plant, 435 feet

Month	State-wide average monthly demand for power in per cent of annual total	Power output with water release to develop maximum primary power. Installed capacity of power plant, 10,000 k.v.a. P.F.=0.80 L.F.=0.75. Average annual power output, 49,600,000 kilowatt hours					Power output with water release in accord with schedule proposed by American River Hydro-electric Company. Installed capacity of power plant, 13,000 k.v.a. P.F.=0.80 L.F.=0.60. Average annual power output, 50,400,000 kilowatt hours				
		Maximum year,* 1909		Minimum year, 1908			Maximum year,** 1909		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year	Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	4,400,000	8.6	4,400,000	9.2	8.6	4,400,000	8.6	4,400,000	11.5	8.6
February	6.9	3,900,000	7.6	3,200,000	6.7	6.3	3,900,000	7.6	4,000,000	10.5	7.8
March	7.8	4,300,000	8.4	3,600,000	7.5	7.0	4,300,000	8.4	4,300,000	11.3	8.4
April	7.9	4,200,000	8.2	3,600,000	7.6	7.0	4,200,000	8.2	4,200,000	11.0	8.2
May	8.8	4,400,000	8.6	4,400,000	9.2	8.6	4,400,000	8.6	4,400,000	11.6	8.6
June	9.0	4,200,000	8.2	4,100,000	8.6	8.0	4,200,000	8.2	4,200,000	11.0	8.2
July	9.4	4,300,000	8.4	4,200,000	8.8	8.2	4,300,000	8.4	4,300,000	11.3	8.4
August	9.5	4,400,000	8.6	4,300,000	9.0	8.4	4,400,000	8.6	2,300,000	6.0	4.5
September	8.7	4,200,000	8.2	4,000,000	8.4	7.8	4,200,000	8.2	600,000	1.6	1.2
October	8.5	4,300,000	8.4	4,000,000	8.4	7.8	4,300,000	8.4	600.000	1.6	1.2
November	8.0	4,200,000	8.2	3,900,000	8.2	7.6	4,200,000	8.2	1,900,000	5.0	3.7
December	8.2	4,400,000	8.6	4,000,000	8.4	7.8	4,400,000	8.6	2,900,000	7.6	5.6
Totals	100.0	51,200,000	100.0	47,700,000	100.0	93.1	51,200,000	100.0	38,100,000	100.0	74.4

*Other years giving maximum power output, 1907 and 1916.
**Maximum power output in all other years except 1913, 1924 and 1925.

Power output from complete consolidated development.

The power output of the consolidated development, when fully completed and operated primarily for power generation, has been assembled and presented in Table 25. Data are given for the two methods of water release, one developing maximum primary power and the other in accord with schedule proposed by American River Hydro-electric Company. The average yearly power output for the period, 1905–1927, under the first method of water release, is estimated at 689,500,000 kilowatt hours. Under the second method of release the average yearly power output for the same period as in the first instance, is 773,100,000 kilowatt hours. A part, 27,000,000 kilowatt hours (32 per cent), of the extra power that could be developed under the second method of water release is due to the additional head available at the Folsom plant with the layout as proposed by the American River Hydro-electric Company. In this layout one unit of the plant would discharge into the American River at an elevation of 38 feet below, and the other unit into the Folsom Canal 7 feet above, the tailrace of the layout in the first instance.

The characteristics of the power output for each method of water release are given in Table 26. It may be noted that for the minimum year, 1924, the output is 65.6 per cent of the maximum, with the method of water release developing maximum primary power, while with the method of release of the American River Hydro-electric Company it is 40.1 per cent of the maximum.

TABLE 25. POWER OUTPUT FROM COMPLETE CONSOLIDATED DEVELOPMENT OPERATED PRIMARILY FOR POWER GENERATION WITH TWO SCHEDULES OF WATER RELEASE

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet

Pilot Creek reservoir—
Height of dam, 110 feet

Webber Creek reservoir—
Height of dam, 90 feet

Year	Power output in kilowatt hours with water release to develop maximum primary power	Power output in kilowatt hours with water release in accord with schedule proposed by American River Hydro-electric Company
	Installed capacity of power plants: Folsom plant, 54,000 k.v.a. P.F.=0.80 L.F.=0.75 Auburn plant, 66,000 k.v.a. P.F.=0.80 L.F.=0.75 Pilot Creek plant, 19,000 k.v.a. P.F.=0.80 L.F.=0.75 Coloma plant, 30,000 k.v.a. P.F.=0.80 L.F.=0.75 Webber Creek plant, 10,000 k.v.a. P.F.=0.80 L.F.=0.75 Total, 179,000 k.v.a. P.F.=0.80 Annual primary power output, 524,700,000 kilowatt hours	Installed capacity of power plants: Folsom plant, 45,000 k.v.a. P.F.=0.80 L.F.=1.00 Auburn plant, 82,000 k.v.a. P.F.=0.80 L.F.=0.60 Pilot Creek plant, 23,000 k.v.a. P.F.=0.80 L.F.=0.60 Coloma plant, 37,000 k.v.a. P.F.=0.80 L.F.=0.60 Webber Creek plant, 13,000 k.v.a. P.F.=0.80 L.F.=0.60 Total, 200,000 k.v.a. P.F.=0.80
1905	674,900,000	753,100,000
1906	776,400,000	852,600,000
1907	825,900,000	874,400,000
1908	619,800,000	761,100,000
1909	809,000,000	877,000,000
1910	705,100,000	853,300,000
1911	752,700,000	870,600,000
1912	608,500,000	659,400,000
1913	642,700,000	601,300,000
1914	734,200,000	853,100,000
1915	724,000,000	841,700,000
1916	776,800,000	866,700,000
1917	693,500,000	846,700,000
1918	599,100,000	703,300,000
1919	623,500,000	747,300,000
1920	636,900,000	671,700,000
1921	726,100,000	839,900,000
1922	694,500,000	823,100,000
1923	716,900,000	855,600,000
1924	541,700,000	351,600,000
1925	621,000,000	769,900,000
1926	617,600,000	680,500,000
1927*	564,500,000	633,600,000
Average	689,500,000	773,100,000

*Partial year, January 1 to October 1.

TABLE 26. CHARACTERISTICS OF POWER OUTPUT FROM COMPLETE CONSOLIDATED DEVELOPMENT OPERATED PRIMARILY FOR POWER GENERATION WITH TWO SCHEDULES OF WATER RELEASE, 1905-1927

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet

Pilot Creek reservoir—
Height of dam, 110 feet

Webber Creek reservoir—
Height of dam, 90 feet

Month	State-wide average monthly demand for power in per cent of annual total	Power output with water release to develop maximum primary power Installed capacity of power plants: Folsom plant, 51,000 k.v.a. P.F.=0.80 L.F.=0.75 Auburn plant, 66,000 k.v.a. P.F.=0.80 L.F.=0.75 Pilot Creek plant, 19,000 k.v.a. P.F.=0.80 L.F.=0.75 Coloma plant, 30,000 k.v.a. P.F.=0.80 L.F.=0.75 Webber Creek plant, 10,000 k.v.a. P.F.=0.80 L.F.=0.75 Total, 179,000 k.v.a. P.F.=0.80 Average annual power output, 689,500,000 kilowatt hours					Power output with water release in accord with schedule proposed by American River Hydro-electric Company Installed capacity of power plants: Folsom plant, 45,000 k.v.a. P.F.=0.80 L.F.=1.00 Auburn plant, 82,000 k.v.a. P.F.=0.80 L.F.=0.60 Pilot Creek plant, 23,000 k.v.a. P.F.=0.80 L.F.=0.60 Coloma plant, 37,000 k.v.a. P.F.=0.80 L.F.=0.60 Webber Creek plant, 13,000 k.v.a. P.F.=0.80 L.F.=0.60 Total, 200,000 k.v.a. P.F.=0.80 Average annual power output, 773,100,000 kilowatt hours.				
		Maximum year, 1907		Minimum year, 1924			Maximum year, 1909		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year	Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	74,000,000	9.0	38,900,000	7.2	4.7	67,200,000	7.7	45,800,000	13.0	5.2
February	6.9	67,200,000	8.1	36,800,000	6.8	4.5	69,300,000	7.9	50,400,000	14.4	5.8
March	7.8	74,300,000	9.0	41,700,000	7.7	5.1	76,900,000	8.8	42,200,000	12.0	4.8
April	7.9	72,000,000	8.7	42,300,000	7.8	5.1	74,200,000	8.4	48,200,000	13.7	5.5
May	8.8	74,400,000	9.0	47,100,000	8.7	5.7	76,900,000	8.8	43,900,000	12.5	5.0
June	9.0	72,000,000	8.7	47,900,000	8.8	5.8	74,200,000	8.4	30,700,000	8.7	3.5
July	9.4	74,300,000	9.0	50,200,000	9.3	6.1	76,200,000	8.7	30,400,000	8.7	3.5
August	9.5	74,200,000	9.0	51,200,000	9.5	6.2	75,600,000	8.6	8,900,000	2.5	1.0
September	8.7	60,300,000	7.3	47,300,000	8.7	5.7	71,100,000	8.1	2,900,000	0.8	0.3
October	8.5	55,100,000	6.7	47,000,000	8.7	5.7	71,600,000	8.2	6,400,000	1.8	0.7
November	8.0	56,100,000	6.8	44,600,000	8.2	5.4	69,300,000	7.9	16,600,000	4.7	1.9
December	8.2	72,000,000	8.7	46,700,000	8.6	5.6	74,500,000	8.5	25,200,000	7.2	2.9
Total	100.0	825,900,000	100.0	541,700,000	100.0	65.6	877,000,000	100.0	351,600,000	100.0	40.1

CHAPTER V

IRRIGATION SERVICE FROM CONSOLIDATED DEVELOPMENT

Importance of consolidated development in comprehensive plan of water development of state.

In formulating the comprehensive plan* for the development of the water resources of the State, it was found that provision must be made for storage works on the streams of the State to equalize the large volumes of flood run-off that occur in the mountain watersheds for the irrigation of agricultural lands lying at lower elevations. The most advantageous postion for these storage works is pointed out on page 23 of Bulletin No. 12, "Summary Report on the Water Resources of California, and a Coordinated Plan for Their Development," published by the Division of Engineering and Irrigation. Here it is stated, "Since these mountain uses (mining and hydro-electric) of water return to the stream channels practically the full amount diverted, reservoirs to re-regulate the flow situated at levels intermediate between the agricultural and the mountain areas will permit the unrestricted development of hydro-electric power and mining in harmony with a complete re-use of the same water on the plains below. Large reservoirs at these intermediate elevations, therefore, are important features of a comprehensive plan to secure the greatest use from the State's waters."

The comprehensive plan of water development for the Sacramento and San Joaquin valleys contemplates the construction of storage reservoirs on Sacramento Valley streams for the purpose of fully suplying the irrigation demands of the Sacramento Valley and in addition releasing a surplus to the needs of the Sacramento Valley to areas of deficient water supply in the San Joaquin Valley. The American River is an important element in this plan for it contributes 13 per cent to the total flow of the Sacramento River, and has a mean annual flow in excess of the irrigation needs of the lands that would naturally be supplied from it. The "Coordinated Plan†" of water development, which selects the units of the comprehensive plan necessary to meet the increasing demands for water in the next fifty years, includes, among other reservoirs in the Sacramento River drainage basin, the Folsom reservoir on the American River. This important reservoir, however, has not sufficient capacity to make available the maximum amount of water for domestic, irrigation and industrial uses capable of being economically developed from the American River. Additional reservoir capacity will be required at some future time to do this. Reservoirs for this purpose in order to avoid conflict with power and mining uses of water must be located on the lower reaches of the stream. The reservoirs of the consolidated development proposed by the American River Hydroelectric Company are in this position and, furthermore, are capable of being developed to large capacity. Therefore, they should be considered an important and necessary part of the comprehensive plan of development of the water resources of the state.

* See Chapter VI, Bulletin No. 4, "Water Resources of California," a report to the Legislature of 1923, published by the Division of Engineering and Irrigation, State Department of Public Works.

† See Bulletin No. 12, "Summary Report on the Water Resources of California and a Coordinated Plan for their Development," published by the Division of Engineering and Irrigation, State Department of Public Works.

Yield of reservoirs of consolidated development in irrigation supply and incidental power.

Estimates have been made of the irrigation yield of the reservoirs of the consolidated development, if operated primarily for irrigation use, for three stages of development. The Folsom reservoir has been considered as a first unit with Auburn and Coloma reservoirs following in order of construction. In estimating the seasonal yield that could be obtained from the reservoirs, it was assumed a total deficiency in the irrigation supply of approximately 50 per cent of a full supply for a season could be endured during the period 1905–1927. This deficiency was permitted to occur in one season or be divided among several. It was also assumed in estimating the yield that no water would be released from the reservoirs during months in which there is no irrigation demand to satisfy the prior right of the Folsom Canal, which supplies the Folsom City power plant of the Pacific Gas and Electric Company. If water were passed for this prior right, the irrigation yield would be reduced to some extent. A deduction was made for evaporation on the surface of the reservoir as in the power estimates. The seasonal irrigation draft was distributed monthly in accord with schedule for the Sacramento Valley floor set forth on page 63 in Bulletin No. 6, "Irrigation Requirements of California Lands," published by Division of Engineering and Irrigation, State Department of Public Works. The distribution is as follows:

TABLE 27. IRRIGATION DEMAND IN PER CENT OF SEASONAL TOTAL

Month	Irrigation demand, in per cent of seasonal total	Month	Irrigation demand, in per cent of seasonal total
January	0	August	20
February	0	September	12
March	1	October	4
April	5	November	0
May	16	December	0
June	20		
July	22	Total	100

The draw-down in a reservoir was limited to that wheh would give a minimum operating head on the power plant of one-half the maximum. This conforms with the assumption made in the operation of these reservoirs, developing maximum primary power. This method of operation resulted in the followng effective reservoir capacities:

TABLE 28. EFFECTIVE CAPACITY OF RESERVOIRS OF CONSOLIDATED DEVELOPMENT OPERATED PRIMARILY FOR IRRIGATION

Reservoir	Total capacity, in acre-feet	Head on power plant, in feet		Effective capacity, in acre-feet
		Maximum	Minimum	
Folsom	355,000	190	95	310,000
Auburn	598,000	385	192	506,000
Coloma	766,000	330	165	686,000
Totals	1,719,000			1,502,000

Information on the irrigation yield and incidental power output is set forth in Tables 29 to 40, inclusive. The irrigation yield, with the Folsom reservoir operating alone, is 664,000 acre-feet per season; with Folsom and Auburn, it is 1,250,000 acre-feet, about twice that from Folsom alone; and for the complete development, Folsom, Auburn and Coloma, is 1,757,000 acre-feet, nearly three times that from Folsom alone and about 60 per cent of the average seasonal run-off from the watershed above Fairoaks. Maximum deficiencies in supply occur in 1924, varying from 28 per cent of a full seasonal supply with Folsom reservoir operated alone, to 40 per cent for Folsom and Auburn together and 41 per cent for the complete development.

The power that could be produced from the irrigation draft has been estimated with the identical power installations used with the reservoir, operated primarily for power generation developing maximum primary power and for three different conditions of load factor, namely: (1) a plant load factor of 75 per cent throughout the year; (2) a plant load factor of 100 per cent throughout the year and (3) a plant load factor of 75 per cent for the first six months, and 100 per cent for the last six months of the year. The figures for the last assumption more nearly represent the amount of power that could be absorbed without waste because the power produced in the last six months of the year would occur when there is a greater demand for hydro-electric power and could be absorbed probably on a 100 per cent load factor, whereas, that produced in the first six months could be absorbed only if operated on a load factor of 75 per cent or less, since there is generally an over supply of hydro-electric power during that period. These data are presented in Tables 29, 30 and 31, for the three stages of development.

The characteristics of the power from the irrigation draft are set forth in Tables 32 to 40, inclusive, for corresponding stages of development and for the three conditions of load factor.

TABLE 29. IRRIGATION YIELD AND POWER OUTPUT OF FOLSOM RESERVOIR OPERATED PRIMARILY FOR IRRIGATION WITH INCIDENTAL POWER

Auburn and Coloma reservoirs not constructed

Height of dam, 190 feet

Capacity of reservoir, 355,000 acre-feet

Seasonal irrigation draft, 664,000 acre-feet (no deduction for downstream prior rights).

Installed capacity of power plant, 43,000 k. v. a. P. F. = 0.80

Maximum deficiency in supply 28.0 per cent in 1924

Year	Seasonal irrigation draft, in acre-feet (no deduction for downstream prior rights)	Deficiency in supply		Power output from irrigation draft delivered at tailrace (elevation 200 feet) of Folsom plant, in kilowatt hours		
		In acre-feet	In per cent of a perfect seasonal supply	Load factor =0.75	Load factor =1.00	Load factor =0.75, January to July. Load factor =1.00, July to January
1905	664,000	0	0	131,700,000	166,000,000	137,000,000
1906	664,000	0	0	173,200,000	221,500,000	186,500,000
1907	664,000	0	0	175,800,000	217,900,000	182,900,000
1908	664,000	0	0	150,700,000	180,300,000	153,200,000
1909	664,000	0	0	190,100,000	237,800,000	202,800,000
1910	664,000	0	0	147,900,000	180,900,000	149,800,000
1911	664,000	0	0	154,500,000	196,000,000	161,000,000
1912	664,000	0	0	120,700,000	139,800,000	123,100,000
1913	664,000	0	0	120,300,000	137,400,000	122,600,000
1914	664,000	0	0	153,800,000	193,100,000	158,100,000
1915	664,000	0	0	139,800,000	171,900,000	142,900,000
1916	664,000	0	0	158,800,000	197,300,000	162,100,000
1917	664,000	0	0	150,600,000	182,600,000	153,600,000
1918	664,000	0	0	114,600,000	135,700,000	116,100,000
1919	625,100	38,900	6	123,800,000	149,600,000	124,800,000
1920	664,000	0	0	126,400,000	151,200,000	134,700,000
1921	664,000	0	0	150,900,000	188,600,000	153,600,000
1922	664,000	0	0	156,500,000	194,300,000	165,300,000
1923	664,000	0	0	152,700,000	190,600,000	155,600,000
1924	480,300	183,700	28	75,000,000	75,400,000	75,200,000
1925	664,000	0	0	132,300,000	163,900,000	134,900,000
1926	556,200	107,800	16	117,900,000	139,200,000	117,900,000
1927	664,000	0	0	*148,400,000	*186,100,000	*151,100,000
Average	649,600	14,400	2.2	143,700,000	175,700,000	147,900,000

*Partial year, January 1 to October 1

TABLE 30. IRRIGATION YIELD AND POWER OUTPUT OF FOLSOM AND AUBURN RESERVOIRS OPERATED PRIMARILY FOR IRRIGATION WITH INCIDENTAL POWER

Coloma reservoir not constructed

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant, 54,000 k.v.a. P.F. = 0.80

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant, 66,000 k.v.a. P.F. = 0.80

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant, 19,000 k.v.a. P.F. = 0.80

Seasonal irrigation draft, 1,250,000 acre-feet (no deduction for downstream prior rights). Maximum deficiency in supply, 40.0 per cent in 1924.

Year	Seasonal irrigation draft, in acre-feet (no deduction for downstream prior rights)	Deficiency in supply		Power output from irrigation draft delivered at tailrace (elevation 200 feet) of Folsom plant, in kilowatt hours		
		In acre-feet	In per cent of a perfect seasonal supply	Load factor =0.75	Load factor =1.00	Load factor =0.75, January to July, Load factor =1.00, July to January
1905	1,250,000	0	0	364,100,000	461.300,000	402,700,000
1906	1,250,000	0	0	447,200,000	567,200,000	486,100,000
1907	1,250,000	0	0	489.500.000	622,600,000	528,400,000
1908	1,250,000	0	0	440,600,000	552,200,000	479,000,000
1909	1,250,000	0	0	572,600,000	736,800,000	625,200,000
1910	1,250,000	0	0	498,100,000	648,200,000	536,200,000
1911	1,250,000	0	0	492,500,000	631,600,000	531,300,000
1912	1,250,000	0	0	323,000,000	399,600,000	361,800,000
1913	1,250,000	0	0	318,400,000	394,300,000	356,500,000
1914	1,250,000	0	0	516,000,000	666,900,000	554,900,000
1915	1,250,000	0	0	452,800,000	573,900,000	491,700,000
1916	1,250,000	0	0	473,000,000	605,200,000	511,900,000
1917	1,250,000	0	0	439,200,000	560,000,000	478,000.000
1918	1,250,000	0	0	340,000,000	432,900,000	376,700,000
1919	1,250,000	0	0	337,300,000	429,900,000	373,700,000
1920	1,250,000	0	0	297,300,000	372,000,000	334,300.000
1921	1,250,000	0	0	477,000,000	615,200,000	515,200,000
1922	1,250,000	0	0	403,000.000	507,600,000	441,900,000
1923	1,250,000	0	0	472,700,000	591,600,000	511,500,000
1924	749,500	500,500	40	158,400,000	186,800,000	158,500,000
1925	1,250,000	0	0	408,300,000	510,900,000	447,200,000
1926	1,153,600	96,400	8	302,600,000	386,800,000	330,600.000
1927	1,250,000	0	0	*440,300,000	*571,900,000	*479,100,000
Average	1,224,000	26,000	2.1	416,000,000	528,500,000	453,300,000

*Partial year, January 1 to October 1.

TABLE 31. IRRIGATION YIELD AND POWER OUTPUT OF FOLSOM, AUBURN AND COLOMA RESERVOIRS OPERATED PRIMARILY FOR IRRIGATION WITH INCIDENTAL POWER

Complete development

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant,
54,000 k.v.a. P.F. =0.80

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant,
66,000 k.v.a. P.F. =0 80

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant,
30,000 k.v.a. P.F. =0.80

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant,
19,000 k.v.a. P.F. =0.80

Webber Creek reservoir—
Height of dam, 90 feet
Installed capacity of power plant,
10,000 k.v.a. P.F. =0.80

Seasonal irrigation draft, 1,757,000 acre-feet (no deduction for downstream prior rights). Maximum deficiency in supply, 41 per cent in 1924

Year	Seasonal irrigation draft, in acre-feet (no deduction for downstream prior rights)	Deficiency in supply		Power output from irrigation draft delivered at tailrace (elevation 200 feet) of Folsom plant, in kilowatt hours		
		In acre-feet	In per cent of a perfect seasonal supply	Load factor =0.75	Load factor =1.00	Load factor =0.75, January to July, Load factor =1.00, July to January
1905	1,757,000	0	0	438,000,000	555,900,000	495,900,000
1906	1,757,000	0	0	527,300,000	679,500,000	590,100,000
1907	1,757,000	0	0	616,700,000	791,900,000	679,400,000
1908	1,757,000	0	0	536,200,000	677,400,000	595,500,000
1909	1,757,000	0	0	715,000,000	925,400,000	782,800,000
1910	1,757,000	0	0	662,300,000	866,200,000	721,400,000
1911	1,757,000	0	0	615,100,000	796,700,000	676,700,000
1912	1,757,000	0	0	418,200,000	521,400,000	475,600,000
1913	1,634,800	122,200	7	356,100,000	442,900,000	394,700,000
1914	1,757,000	0	0	620,900,000	798,600,000	682,500,000
1915	1,757,000	0	0	549,600,000	697,600,000	611,200,000
1916	1,757,000	0	0	587,900,000	764,900,000	649,500,000
1917	1,757,000	0	0	532,900,000	686,300,000	594,400,000
1918	1,757,000	0	0	442,700,000	566,500,000	499,400,000
1919	1,757,000	0	0	435,800,000	560,000,000	492,800,000
1920	1,706,100	50,900	3	374,300,000	471,500,000	423,000,000
1921	1,757,000	0	0	551,200,000	715,000,000	612,600,000
1922	1,757,000	0	0	480,300,000	614,600,000	512,000,000
1923	1,757,000	0	0	568,500,000	726,200,000	628,300,000
1924	1,031,100	725,900	41	215,400,000	264,200,000	224,400,000
1925	1,757,000	0	0	480,900,000	607,500,000	540,300,000
1926	1,757,000	0	0	394,100,000	508,300,000	448,300,000
1927	1,757,000	0	0	*526,200,000	*690,200,000	*587,700,000
Average	1,717,900	39,100	2.2	511,900,000	656,400,000	569,200,000

*Partial year January 1 to October 1.

TABLE 32. CHARACTERISTICS OF POWER OUTPUT OF FOLSOM PLANT WITH FOLSOM RESERVOIR OPERATED PRIMARILY FOR IRRIGATION WITH INCIDENTAL POWER

Auburn and Coloma reservoirs not constructed

1905–1927

Height of dam, 190 feet — Load Factor =0.75 — Capacity of reservoir, 335,000 acre-feet

Installed capacity of power plant, 43,000 k. v. a. P. F. =0.80

Seasonal irrigation draft, 664,000 acre-feet (no deduction for downstream prior rights)

Maximum deficiency in supply, 28 per cent in 1924 — Average annual power output, 143,700,000 kilowatt hours.

Month	State-wide average monthly demand for power in per cent of annual total	Power output from irrigation draft delivered at tailrace (elevation 200 feet) of Folsom plant				
		Maximum year, 1909		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	18,000,000	9.5	0	0	0
February	6.9	16,200,000	8.5	0	0	0
March	7.8	18,000,000	9.5	7,800,000	10.4	4.1
April	7.9	17,400,000	9.1	16,000,000	21.3	8.4
May	8.8	18,000,000	9.5	15,300,000	20.4	8.1
June	9.0	17,400,000	9.1	17,400,000	23.2	9.2
July	9.4	18,000,000	9.5	14,500,000	19.3	7.6
August	9.5	18,000,000	9.5	1,500,000	2.0	0.8
September	8.7	10,300,000	5.4	800,000	1.1	0.4
October	8.5	3,400,000	1.8	1,700,000	2.3	0.9
November	8.0	17,400,000	9.1	0	0	0
December	8.2	18,000,000	9.5	0	0	0
Totals	100.0	190,100,000	100.0	75,000,000	100.0	39.5

TABLE 33. CHARACTERISTICS OF POWER OUTPUT OF FOLSOM PLANT WITH FOLSOM RESERVOIR OPERATED PRIMARILY FOR IRRIGATION WITH INCIDENTAL POWER

Auburn and Coloma reservoirs not constructed
1905-1927

Height of dam, 190 feet — Load factor =1.00 — Capacity of reservoir, 355,000 acre-feet

Installed capacity of power plant, 43,000 k. v. a. P. F. =0.80.

Seasonal irrigation draft, 664,000 acre-feet (no deduction for downstream prior rights)

Maximum deficiency in supply, 28 per cent in 1924 — Average annual power output, 175,700,000 kilowatt hours

Month	State-wide average monthly demand for power in per cent of annual total	Power output from irrigation draft delivered at tailrace (elevation 200 feet) of Folsom plant				
		Maximum year, 1909		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	24,000,000	10.1	0	0	0
February	6.9	21,600,000	9.1	0	0	0
March	7.8	24,000,000	10.1	7,800,000	10.3	3.3
April	7.9	23,200,000	9.8	16,000,000	21.2	6.7
May	8.8	24,000,000	10.1	15,300,000	20.3	6.5
June	9.0	23,200,000	9.8	17,600,000	23.3	7.4
July	9.4	21,300,000	8.9	14,700,000	19.5	6.2
August	9.5	18,600,000	7.8	1,500,000	2.0	0.6
September	8.7	10,300,000	4.3	800,000	1.1	0.3
October	8.5	3,400,000	1.4	1,700,000	2.3	0.7
November	8.0	20,200,000	8.5	0	0	0
December	8.2	24,000,000	10.1	0	0	0
Totals	100.0	237,800,000	100.0	75,400,000	100.0	31.7

TABLE 34. CHARACTERISTICS OF POWER OUTPUT OF FOLSOM PLANT WITH FOLSOM RESERVOIR OPERATED PRIMARILY FOR IRRIGATION WITH INCIDENTAL POWER

Auburn and Coloma reservoirs not constructed

1905-1927

Load factor =0.75, January to July
Load factor =1.00, July to January

Height of dam, 190 feet

Capacity of reservoir, 355,000 acre-feet

Installed capacity of power plant, 43,000 k. v. a. P. F. =0.80.

Seasonal irrigation draft, 664,000 acre-feet (no deduction for downstream prior rights)

Maximum deficiency in supply, 28 per cent in 1924

Average annual power output, 147,900,000 kilowatt hours

Month	State-wide average monthly demand for power in per cent of annual total	Power output from irrigation draft delivered at tailrace (elevation 200 feet) of Folsom plant				
		Maximum year, 1909		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	18,000,000	8.9	0	0	0
February	6.9	16,200,000	8.0	0	0	0
March	7.8	18,000,000	8.9	7,800,000	10.4	3.9
April	7.9	17,400,000	8.6	16,000,000	21.3	7.9
May	8.8	18,000,000	8.9	15,300,000	20.3	7.5
June	9.0	17,400,000	8.6	17,400,000	23.1	8.6
July	9.4	21,300,000	10.5	14,700,000	19.5	7.3
August	9.5	18,600,000	9.1	1,500,000	2.0	0.7
September	8.7	10,300,000	5.1	800,000	1.1	0.4
October	8.5	3,400,000	1.7	1,700,000	2.3	0.8
November	8.0	20,200,000	9.9	0	0	0
December	8.2	24,000,000	11.8	0	0	0
Totals	100.0	202,800,000	100.0	75,200,000	100.0	37.1

TABLE 35. CHARACTERISTICS OF POWER OUTPUT OF FOLSOM, AUBURN AND PILOT CREEK PLANTS WITH FOLSOM AND AUBURN RESERVOIRS OPERATED PRIMARILY FOR IRRIGATION WITH INCIDENTAL POWER

Coloma reservoir not constructed

1905-1927

Load factor =0.75

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant, 54,000 k v.a. P.F. =0.80

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant, 66,000 k.v.a. P.F. =0.80

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant, 19,000 k.v.a. P.F. =0.80

Seasonal irrigation draft, 1,250,000 acre-feet (no deduction for downstream prior rights)

Maximum deficiency in supply, 40 per cent in 1924

Average annual power output, 416,000,000 kilowatt hours

Month	State-wide average monthly demand for power in per cent of annual total	Power output from irrigation draft delivered at tailrace (elevation 200 feet) of Folsom plant				
		Maximum year, 1909		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	56,300,000	9.8	0	0	0
February	6.9	52,000,000	9.0	0	0	0
March	7.8	57,500,000	10.1	4,000,000	2.5	0.7
April	7.9	55,600,000	9.7	21,900,000	13.8	3.8
May	8.8	57,500,000	10.1	56,800,000	35.8	9.9
June	9.0	55,600,000	9.7	48,100,000	30.4	8.4
July	9.4	57,500,000	10.1	21,500,000	13.6	3.8
August	9.5	57,500,000	10.1	800,000	0.5	0.2
September	8.7	49,700,000	8.6	1,200,000	0.8	0.2
October	8.5	15,900,000	2.7	4,100,000	2.6	0.7
November	8.0	0	0	0	0	0
December	8.2	57,500,000	10.1	0	0	0
Totals	100.0	572,600,000	100.0	158,400,000	100.0	27.7

TABLE 36. CHARACTERISTICS OF POWER OUTPUT OF FOLSOM, AUBURN AND PILOT CREEK PLANTS WITH FOLSOM AND AUBURN RESERVOIRS OPERATED PRIMARILY FOR IRRIGATION WITH INCIDENTAL POWER

Coloma reservoir not constructed

1905-1927

Load factor = 1.00

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant, 54,000 k.v.a. P.F. = 0.80

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant, 66,000 k.v.a. P.F. = 0.80

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant, 19,000 k.v.a. P.F. = 0.80

Seasonal irrigation draft, 1,250,000 acre-feet (no deduction for downstream prior rights)

Maximum deficiency in supply, 40 per cent in 1924.

Average annual power output, 528,500,000 kilowatt hours

Month	State-wide average monthly demand for power in per cent of annual total	Power output from irrigation draft delivered at tailrace (elevation 200 feet) of Folsom plant				
		Maximum year, 1909		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	75,100,000	10.2	0	0	0
February	6.9	69,300,000	9.4	0	0	0
March	7.8	76,700,000	10.4	4,000,000	2.2	0.5
April	7.9	74,100,000	10.1	21,900,000	11.7	3.0
May	8.8	76,700,000	10.4	69,000,000	37.0	9.4
June	9.0	74,100,000	10.1	64,100,000	34.3	8.7
July	9.4	76,700,000	10.4	21,700,000	11.6	2.9
August	9.5	76,700,000	10.4	800,000	0.4	0.1
September	8.7	50,300,000	6.8	1,200,000	0.6	0.2
October	8.5	15,900,000	2.2	4,100,000	2.2	0.6
November	8.0	0	0	0	0	0
December	8.2	71,200,000	9.6	0	0	0
Totals	100.0	736,800,000	100.0	186,800,000	100.0	25.4

TABLE 37. CHARACTERISTICS OF POWER OUTPUT OF FOLSOM, AUBURN AND PILOT CREEK PLANTS WITH FOLSOM AND AUBURN RESERVOIRS OPERATED PRIMARILY FOR IRRIGATION WITH INCIDENTAL POWER

Coloma reservoir not constructed

1905-1927

Load factor =0.75 January to July
Load factor =1.00 July to January

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant, 54,000 k.v.a. P.F. =0.80

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant, 66,000 k.v.a. P.F. =0.80

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant, 19,000 k.v.a. P.F. =0.80

Seasonal irrigation draft, 1,250,000 acre-feet (no deduction for downstream prior rights)

Maximum deficiency in supply, 40 per cent in 1924

Average annual power output, 453,300,000 kilowatt hours

Month	State-wide average monthly demand for power in per cent of annual total	Power output from irrigation draft delivered at tailrace (elevation 200 feet) of Folsom plant				
		Maximum year, 1909		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	56,300,000	9.0	0	0	0
February	6.9	52,000,000	8.3	0	0	0
March	7.8	57,500,000	9.2	4,000,000	2.5	0.6
April	7.9	55,600,000	8.9	21,900,000	13.8	3.5
May	8.8	57,500,000	9.2	56,800,000	35.8	9.1
June	9.0	55,600,000	8.9	48,000,000	30.3	7.7
July	9.4	76,700,000	12.3	21,700,000	13.7	3.5
August	9.5	76,700,000	12.3	800,000	0.5	0.1
September	8.7	50,200,000	8.0	1,200,000	0.8	0.2
October	8.5	15,900,000	2.5	4,100,000	2.6	0.7
November	8.0	0	0	0	0	0
December	8.2	71,200,000	11.4	0	0	0
Totals	100.0	625,200,000	100.0	158,500,000	100.0	25.4

TABLE 38. CHARACTERISTICS OF POWER OUTPUT OF FOLSOM, AUBURN, PILOT CREEK, COLOMA AND WEBBER CREEK PLANTS, WITH FOLSOM, AUBURN AND COLOMA RESERVOIRS OPERATED PRIMARILY FOR IRRIGATION WITH INCIDENTAL POWER

Complete development—1905-1927

Load factor = 0.75

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant,
54,000 k.v.a. P.F. = 0.80

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant,
66,000 k.v.a. P.F. = 0.80

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant,
30,000 k.v.a. P.F. = 0.80

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant,
19,000 k.v.a. P.F. = 0.80

Webber Creek reservoir—
Height of dam, 90 feet
Installed capacity of power plant,
10,000 k.v.a. P.F. = 0.80

Seasonal irrigation draft, 1,757,000 acre-feet (no deduction for downstream prior rights)

Maximum deficiency in supply, 41 per cent in 1924

Average annual power output, 511,900,000 kilowatt hours

Month	State-wide average monthly demand for power in per cent of annual total	Power output from irrigation draft delivered at tailrace (elevation 200 feet) of Folsom plant				
		Maximum year, 1909		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	73,200,000	10.2	0	0	0
February	6.9	67,200,000	9.4	0	0	0
March	7.8	74,400,000	10.4	6,300,000	2.9	0.9
April	7.9	71,900,000	10.1	33,300,000	15.5	4.6
May	8.8	74,400,000	10.4	73,700,000	34.2	10.3
June	9.0	71,900,000	10.1	60,800,000	28.2	8.5
July	9.4	74,300,000	10.4	31,200,000	14.5	4.3
August	9.5	74,300,000	10.4	2,000,000	0.9	0.3
September	8.7	68,500,000	9.6	2,600,000	1.2	0.4
October	8.5	27,400,000	3.8	5,500,000	2.6	0.8
November	8.0	0	0	0	0	0
December	8.2	37,500,000	5.2	0	0	0
Totals	100.0	715,000,000	100.0	215,400,000	100.0	30.1

TABLE 39. CHARACTERISTICS OF POWER OUTPUT OF FOLSOM, AUBURN, PILOT CREEK, COLOMA AND WEBBER CREEK PLANTS, WITH FOLSOM, AUBURN AND COLOMA RESERVOIRS OPERATED PRIMARILY FOR IRRIGATION WITH INCIDENTAL POWER

Complete development—1905-1927

Load factor = 1.00

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant, 54,000 k.v.a. P.F. = 0.80

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant, 66,000 k.v.a. P.F. = 0.80

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant, 30,000 k.v.a. P.F = 0.80

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant, 19,000 k.v.a. P.F. = 0.80

Webber Creek reservoir—
Height of dam, 90 feet
Installed capacity of power plant, 10,000 k.v.a. P.F. = 0.80

Seasonal irrigation draft, 1,757,000 acre-feet (no deduction for downstream prior rights)

Maximum deficiency in supply, 41 per cent in 1924

Average annual power output, 656,400,000 kilowatt hours

Month	State-wide average monthly demand for power in per cent of annual total	Power output from irrigation draft delivered at tailrace (elevation 200 feet) of Folsom plant				
		Maximum year, 1909		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	95,900,000	10.4	0	0	0
February	6.9	89,600,000	9.7	0	0	0
March	7.8	99,200,000	10.7	6,400,000	2.4	0.7
April	7.9	95,800,000	10.4	33,300,000	12.6	3.6
May	8.8	99,200,000	10.7	93,100,000	35.2	10.1
June	9.0	95,800,000	10.4	81,000,000	30.7	8.7
July	9.4	99,200,000	10.7	40,300,000	15.2	4.3
August	9.5	99,200,000	10.7	2,000,000	0.8	0.2
September	8.7	80,500,000	8.7	2,600,000	1.0	0.3
October	8.5	27,300,000	2.9	5,500,000	2.1	0.6
November	8.0	0	0	0	0	0
December	8.2	43,700,000	4.7	0	0	0
Totals	100.0	925,400,000	100.0	264,200,000	100.0	28.5

TABLE 40. CHARACTERISTICS OF POWER OUTPUT OF FOLSOM, AUBURN, PILOT CREEK, COLOMA AND WEBBER CREEK PLANTS, WITH FOLSOM, AUBURN AND COLOMA RESERVOIRS OPERATED PRIMARILY FOR IRRIGATION WITH INCIDENTAL POWER

Complete development—1905-1927

Load factor = 0.75 January to July
Load factor = 1.00 July to January

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant, 54,000 k.v.a. P.F. = 0.80

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant, 66,000 k.v.a. P.F. = 0.80

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant, 30,000 k.v.a. P.F. = 0.80

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant, 19,000 k.v.a. P.F. = 0.80

Webber Creek reservoir—
Height of dam, 90 feet
Installed capacity of power plant, 10,000 k.v.a. P.F. = 0.80

Seasonal irrigation draft, 1,757,000 acre-feet (no deduction for downstream prior rights)

Maximum deficiency in supply, 41 per cent in 1924

Average annual power output, 569,200,000 kilowatt hours

Month	State-wide average monthly demand for power in per cent of annual total	Power output from irrigation draft delivered at tailrace (elevation 200 feet) of Folsom plant				
		Maximum year, 1909		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	73,200,000	9.3	0	0	0
February	6.9	67,200,000	8.6	0	0	0
March	7.8	74,400,000	9.5	6,300,000	2.8	0.8
April	7.9	71,900,000	9.2	33,300,000	14.8	4.3
May	8.8	74,400,000	9.5	73,700,000	32.8	9.4
June	9.0	71,900,000	9.2	60,700,000	27.0	7.8
July	9.4	99,200,000	12.7	40,300,000	18.0	5.1
August	9.5	99,200,000	12.7	2,000,000	0.9	0.3
September	8.7	80,400,000	10.2	2,600,000	1.2	0.3
October	8.5	27,300,000	3.5	5,500,000	2.5	0.7
November	8.0	0	0	0	0	0
December	8.2	43,700,000	5.6	0	0	0
Totals	100.0	782,800,000	100.0	224,400,000	100.0	28.7

A considerable irrigation yield could be obtained from reservoirs of the consolidated development if operated primarily for the generation of power. The yield has been estimated under this condition for the period 1905–1927 for the three stages of development. It is based on the same average deficiency in supply for the period as when the reservoirs were operated primarily for irrigation purposes.

In Tables 41 and 42 are set forth, by years, from 1905 to 1927, seasonal irrigation draft, deficiency in supply in acre-feet and in per cent of perfect seasonal supply, for the three stages of development. In Table 41 is presented information for the method of water release developing maximum primary power, and in Table 42, that for the method of release proposed by the American River Hydro-electric Company. With the first method of release, the seasonal draft ranges from 297,000 acre-feet per season for the first stage of development with Folsom reservoir alone, to 578,000 acre-feet for the complete development. Corresponding values with the second method of water release are 49,600 and 729,000 acre-feet. The average deficiency in supply per year is about 2 per cent in each case; however, the maximum deficiency is as much as 46 per cent with the second method of water release, whereas, with the first method it is 5 per cent, with a greater number of years of deficiency.

TABLE 41. IRRIGATION YIELD OF RESERVOIRS OF CONSOLIDATED DEVELOPMENT OPERATED PRIMARILY FOR POWER GENERATION WITH WATER RELEASE TO DEVELOP MAXIMUM PRIMARY POWER

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant,
*43,000 k.v a. P.F. =0.80 L.F. =0.75
54,000 k.v.a. P.F. =0.80 L.F. =0.75

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant,
66,000 k.v.a. P.F. =0.80 L.F =0 75

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant,
30,000 k.v.a. P.F. =0.80 L.F. =0.75

Year	Folsom reservoir			Folsom and Auburn reservoirs			Folsom, Auburn and Coloma reservoirs		
	Seasonal irrigation draft, in acre-feet (no deduction for down-stream prior rights)	Deficiency in supply		Seasonal irrigation draft, in acre-feet (no deduction for down-stream prior rights)	Deficiency in supply		Seasonal irrigation draft, in acre-feet (no deduction for down-stream prior rights)	Deficiency in supply	
		In acre-feet	In per cent of a perfect seasonal supply		In acre-feet	In per cent of a perfect seasonal supply		In acre-feet	In per cent of a perfect seasonal supply
1905	285,100	11,900	4	415,800	14,200	3	562,500	15,500	3
1906	297,000	0	0	430,000	0	0	578,000	0	0
1907	297,000	0	0	430,000	0	0	578,000	0	0
1908	284,800	12,200	4	415,600	14,400	3	562,500	15,500	3
1909	297,000	0	0	430,000	0	0	578,000	0	0
1910	285,800	11,200	4	416,500	13,500	3	562,500	15,500	3
1911	297,000	0	0	430,000	0	0	578,000	0	0
1912	284,400	12,600	4	415,100	14,900	3	562,200	15,800	3
1913	285,300	11,700	4	415,800	14,200	3	562,500	15,500	3
1914	297,000	0	0	430,000	0	0	578,000	0	0
1915	297,000	0	0	430,000	0	0	568,000	10,000	2
1916	297,000	0	0	430,000	0	0	578,000	0	0
1917	297,000	0	0	430,000	0	0	562,200	15,800	3
1918	286,900	10,100	3	416,700	13,300	3	553,900	24,100	4
1919	286,800	10,200	3	414,100	15,900	4	555,600	22,400	4
1920	285,700	11,300	4	415,800	14,200	3	562,500	15,500	3
1921	294,400	2,600	1	414,400	15,600	4	562,500	15,500	3
1922	294,400	2,600	1	423,300	6,700	2	561,600	16,400	3
1923	294,200	2,800	1	426,500	3,500	1	560,700	17,300	3
1924	285,900	11,100	4	425,700	4,300	1	578,000	0	0
1925	290,100	6,900	2	415,300	14,700	3	562,500	15,500	3
1926	282,400	14,600	5	411,400	18,600	4	556,200	21,800	4
1927	294,400	2,600	1	415,100	14,900	3	562,500	15,500	3
Average	291,200	5,800	2.0	421,600	8,400	1.9	566,400	11,600	2.2

*Auburn and Coloma reservoirs not constructed.

TABLE 42. IRRIGATION YIELD OF RESERVOIRS OF CONSOLIDATED DEVELOPMENT OPERATED PRIMARILY FOR POWER GENERATION WITH WATER RELEASE IN ACCORD WITH SCHEDULE PROPOSED BY AMERICAN RIVER HYDRO-ELECTRIC CO.

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant,
*35,000 k.v.a. P.F. =0.80 L.F. =1.00
45,000 k.v.a. P.F. =0.80 L.F. =1.00

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant,
82,000 k.v.a. P.F. =0.80 L.F. =0.60

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant,
37,000 k.v.a. P.F. =0.80 L.F =0.60

Year	Folsom reservoir			Folsom and Auburn reservoirs			Folsom, Auburn and Coloma reservoirs		
	Seasonal irrigation draft, in acre-feet (no deduction for down-stream prior rights)	Deficiency in supply		Seasonal irrigation draft, in acre-feet (no deduction for down-stream prior rights)	Deficiency in supply		Seasonal irrigation draft, in acre-feet (no deduction for down-stream prior rights)	Deficiency in supply	
		In acre-feet	In per cent of a perfect seasonal supply		In acre-feet	In per cent of a perfect seasonal supply		In acre-feet	In per cent of a perfect seasonal supply
1905	49,600	0	0	96,000	0	0	722,300	6,700	1
1906	49,600	0	0	96,000	0	0	729,000	0	0
1907	49,600	0	0	96,000	0	0	729,000	0	0
1908	49,600	0	0	96,000	0	0	722,300	6,700	1
1909	49,600	0	0	96,000	0	0	722,300	6,700	1
1910	49,600	0	0	96,000	0	0	722,300	6,700	1
1911	49,600	0	0	96,000	0	0	729,000	0	0
1912	49,600	0	0	96,000	0	0	722,300	6,700	1
1913	49,600	0	0	96,000	0	0	722,300	6,700	1
1914	49,600	0	0	96,000	0	0	722,300	6,700	1
1915	49,600	0	0	96,000	0	0	722,300	6,700	1
1916	49,600	0	0	96,000	0	0	722,300	6,700	1
1917	49,600	0	0	96,000	0	0	722,300	6,700	1
1918	49,600	0	0	96,000	0	0	722,300	6,700	1
1919	49,600	0	0	96,000	0	0	722,300	6,700	1
1920	49,600	0	0	96,000	0	0	722,300	6,700	1
1921	49,600	0	0	96,000	0	0	722,300	6,700	1
1922	49,600	0	0	96,000	0	0	722,300	6,700	1
1923	49,600	0	0	96,000	0	0	722,300	6,700	1
1924	26,800	22,800	46	41,800	44,200	46	523,000	206,000	28
1925	49,600	0	0	96,000	0	0	722,300	6,700	1
1926	49,600	0	0	96,000	0	0	722,300	6,700	1
1927	49,600	0	0	96,000	0	0	722,300	6,700	1
Average	48,600	1,000	2.0	93,600	1,900	2.0	714,500	14,500	2.0

*Auburn and Coloma reservoirs not constructed.

Area of irrigation service from consolidated development.

The area that could be irrigated from the reservoirs of the consolidated development, including the areas now being irrigated from the American River below Folsom dam, and assuming that the operation of the Folsom City power plant would be subordinated to the use of the reservoirs for irrigation, is set forth in Table 43. These figures are based on the data presented in the previous tables in this chapter. In estimating the area capable of irrigation under the various conditions, a seasonal duty of 2.5 acre-feet per acre of net area has been assumed. The deficiencies in supply are given in the table both as an average seasonal amount for the period of analysis and for the maximum year. The average flow in August below the Folsom dam is also given for the several conditions, assuming that the entire supply for irrigation would be delivered below this dam. Values are set forth for the maximum and minimum years and the average for the period 1905–1927.

TABLE 43. IRRIGATION SERVICE FROM CONSOLIDATED DEVELOPMENT

Areas now being supplied from American River included

Operation of the Folsom City power plant of the Pacific Gas & Electric Company subordinated to the use of the reservoirs for irrigation

1905-1927

Stage of development	Reservoirs operated primarily for irrigation						Reservoirs operated primarily for power											
							Water release to develop maximum primary power						Water release in accord with schedule proposed by American River Hydro-electric Company					
	Area irrigable in acres (seasonal duty, 2.5 acre-feet per acre)	Deficiency in supply, in per cent of a perfect seasonal supply		Average flow in August below Folsom dam in second-feet			Area irrigable in acres (seasonal duty 2.5 acre-feet per acre)	Deficiency in supply, in per cent of a perfect seasonal supply		Average flow in August below Folsom dam, in second-feet			Area irrigable in acres (seasonal duty 2.5 acre-feet per acre)	Deficiency in supply, in per cent of a perfect seasonal supply		Average flow in August below Folsom dam, in second feet		
		Average for period 1905-1927	In year of maximum deficiency	Average for period 1905-1927	Maximum year	Minimum year 1924		Average for period, 1905-1927	In year of maximum deficiency	Average for period, 1905-1927	Maximum year	Minimum year 1924		Average for period, 1905-1927	In year of maximum deficiency	Average for period, 1905-1927	Maximum year	Minimum year, 1924
Folsom reservoir	266,000	2.2	28	2050	*2160	330	119,000	2.0	5.0	1060	2020	920	20,000	2.0	46.0	1910	2000	16
Folsom and Auburn reservoir	500,000	2.1	40	3890	**4070	140	172,000	1.9	4.0	1510	2530	1350	38,000	2.0	46.0	2400	2500	120
Folsom, Auburn and Coloma reservoir	703,000	2.2	41	5470	**5710	120	231,000	2.2	4.0	1907	2510	1860	292,000	2.0	28.0	2410	2500	430

*In all years except 1924 and 1926.
**In all years except 1924.

Agricultural lands in Sacramento Valley capable of irrigation from American River.

North and south of the American River and east of the Sacramento and Feather rivers, there is a gross area of 350,000 acres of valley floor and plains lands, whose natural and economic source of irrigation supply lies in the American River. This area is shown in yellow on Plate II. Lands within the reclamation districts adjacent to the Sacramento and Feather rivers and American River near its confluence with the Sacramento River, aggregating 130,000 acres, although physically possible of being served by gravity from the American River, have not been included because it is thought they could more easily and economically be supplied by pumping from the Feather and Sacramento rivers. Areas within the confines of these districts are largely so supplied at the present time.

The area north of the American River comprises both plains and valley lands, a gross total of 200,000 acres. About 65 per cent of this area could be served by a diversion from the American River from the tailrace of the Folsom plant with the tail-water maintained at elevation 200 feet. The remainder, 35 per cent, would require water to be diverted above the Folsom reservoir, probably at the Pilot Creek dam. This water would be lost for power generation at the Folsom plant. It is estimated that the ultimate net irrigated area will be 140,000 acres. Assuming a seasonal duty of 2.5 acre-feet per acre per season a total of 350,000 acre-feet per season would be required for the irrigation of these lands.

On the south side of the American Rver there is a gross area of 150,000 acres lying north of the Cosumnes River between the foothills on the east and the eastern boundaries of the reclamation districts on the west, that are classified as agricultural. These lands or their equivalent in area will probably be irrigated from the American at some future date. All of these lands indicated on Plate II could be irrigated with a diversion at elevation 200 feet. The Folsom Canal enlarged to adequate capacity could be utilized for the upper part of the diversion canal. The plans of the American River Hydro-electric Company call for the construction of a power plant below the Folsom dam, one unit of which would discharge into the American River below the Prison dam at elevation 162 feet. If these plans were consummated, it would be a difficult and costly undertaking to divert the tail-water of this unit at any point upstream to the Folsom City plant because of topographic and physical features of the canyon. It is believed that it would not be practicable, under these conditions, to effect a diversion at a higher elevation than 110 feet. This would reduce the area capable of being served by 30 per cent. It appears that the most feasible solution would require the Folsom plant to discharge the tail-water of the lower unit, also, into the Folsom Canal, placing the water in a position to serve the entire area considered. Many years may elapse before plans are perfected for the utilization of this water for irrigation. In the interim, it could be used for the generation of power at the Folsom City plant, if deemed advisable. It is estimated that about 120,000 acres of the total of 150,000 would be ultimately irrigated. With a seasonal duty of 2.5 acre-feet per acre per season, the same as assumed for the area north of the river, the irrigation requirement in one season would be 300,000 acre-feet.

Therefore, the estimated total irrigation requirement for full development of the 350,000 acres gross or 260,000 acres net outlined in yellow on Plate II is 650,000 acre-feet per season. Referring to Table 43, it may be noted that 46 per cent of this area could be irrigated from the Folsom reservoir, 66 per cent from Folsom and Auburn, and 89 per cent with complete reservoir development with reservoirs operated primarily for power generation to develop maximum primary power. If the reservoirs were operated in accord with schedule of water release proposed by the American River Hydro-electric Company, the corresponding figures would be 8, 15 and 112 per cent. These figures are based on the assumption that the water would be diverted by gravity at the proper elevations to serve the areas under consideration and include areas now being served from the American River, downstream from the Folsom dam.

CHAPTER VI

UTILIZATION OF RESERVOIRS OF CONSOLIDATED DEVELOPMENT FOR CONTROL OF FLOODS ON AMERICAN RIVER

Necessity for flood control on American River.

The need for flood control to protect areas subject to overflow along the lower American River has long been recognized, as witnessed by acts of the national and state legislative bodies. The United States Congress in 1917 and the State Legislature in 1911 adopted a general plan of flood control for the Sacramento Valley. In this plan provision was included for the flood control on the lower American River. The State Legislature, in 1927, at the urgent request of interested parties, created the American River Flood Control District, which comprises the cities of Sacramento and North Sacramento as well as contiguous unincorporated territory in Sacramento County, containing an area of approximately 23,000 acres. This district is now actively engaged in an investigation of the flood situation in an effort to formulate a plan that, when consummated, will adequately protect it from the flood menace.

Concrete evidence of the necessity of flood protection was furnished during the past year when a flood of large proportions passed down the river on March 25, 1928, overflowing its banks and inundating 13,000 acres of inhabited area. The city of North Sacramento was within the flooded area. Large damages were suffered by private and public interests. Highway communication on the Pacific Highway was severed for several days with great inconvenience to the public.

Plans for flood control.

Several plans for the protection of this densely populated area from disastrous floods have been proposed in the past. They can be divided naturally into two general systems of control, with and without supplementary control by reservoirs that could be constructed upstream from the affected area. Each system would require the creation of a definite channel of adequate capacity for the confinement of the flood waters that must pass the overflow area. The flood channel would be formed by levees on either side of the main channel of the river. The spacing of the levees would be conditioned upon the system of control considered. With supplementary reservoir control, floods could be reduced to a size that would be confined in a flood channel with levees spaced about one-half the distance required without reservoir control, and afford the same degree of protection.

The adopted plan of the Sacramento Flood Control Project for the American River contemplates a flood channel, 2400 feet wide, without upstream reservoir control. However, the California Debris Commission, in its report* of 1925, states: "However, various other plans have been suggested, especially with a view to benefitting certain local interests, and the commission recommends that no objection be made to such modifications when proposed in the future, should it be possible to reduce the cost of the project to the government by acceding to such changes."

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* Senate document No. 23, 69th Congress, 1st session "Flood Control in the Sacramento and San Joaquin River Systems."

Supplementary reservoir control would permit of a modification of the adopted flood control plan since flood flows would be reduced in size by this system of control.

This report presents the possibilities of flood reduction by the utilization of space for flood control in the reservoirs of the consolidated development.

Data used and methods employed in analysis of flood flows.

In analyzing the flood flow of the American River for the purpose of estimating the utility of the reservoirs of the consolidated development in controlling floods on the lower American River, measurements and records of the United States Geological Survey for the Fairoaks gaging station were used as published in the water supply papers and in preparation for publication. Estimates of flood discharge based on high water marks established from memory of old inhabitants are believed to be too unreliable and have not been included in the data used in the preparation of this report. The only authentic records that are available are those of the United States Geological Survey.

The methods employed in analyzing these flood data as set forth in this report are fully described in Bulletin No. 14, ''The Control of Floods by Reservoirs,'' recently published by the Division of Engineering and Irrigation, State Department of Public Works. Therefore, the analyses in this report are presented without detailed discussion and explanation.

Floods of record.

Measurements have been made on the American River at the Fairoaks gaging station by the United States Geological Survey from October, 1904 to date. The area above this station includes practically the entire drainage area of the river. The records show that the largest flood during this period occurred on March 25, 1928, with a crest discharge of 184,000 second-feet, the mean for the day being 120,000 second-feet. The second largest flood occurred on March 19, 1907, when 119,000 second-feet crest flow passed the gaging station, with the mean for the day of 105,000 second-feet. Table 44 sets forth, in order of decreasing magnitude, data on the twenty largest floods during the period of stream measurement. Values of maximum mean daily flow vary from a maximum of 120,000 to a minimum of 34,000 second-feet. These figures are the mean for the day extending from midnight to midnight in each instance.

Measurements are also available from which may be determined the maximum twenty-four-hour flow for the 1928 and 1927 floods. In the 1928 flood, the maximum twenty-four-hour period was from 10 a.m. on March 25 to 10 a.m. on March 26, with a mean flow of 148,000 second-feet, which is 23.3 per cent larger than the maximum mean daily flow. In the 1927 flood, the period of maximum twenty-four-hour flow was from 9 a.m. February 21 to 9 a.m. February 22, with a mean flow of 58,000 second-feet, which is 20.3 per cent larger than the maximum mean daily flow of 48,200 second-feet.

The crest flow for any flood is considerably larger than maximum mean daily flow or for the maximum twenty-four-hour flow. Values are available only for three large floods on the American River. The crest flow for the 1928 flood was 184,000 second-feet, 53 per cent larger than the maximum mean daily flow and 24 per cent larger than the maximum twenty-four-hour flow. For the 1927 flood, the crest flow was 68,000 second-feet, 41 per cent larger than the maximum mean daily flow and 17 per cent larger than the maximum twenty-four-hour flow of 58,000 second-feet. The crest flow of the 1907 flood was estimated at 119,000 second-feet, 13 per cent greater than the maximum mean daily flow. Data are not available for estimating the maximum twenty-four-hour flow.

In addition to the larger floods listed in Table 44, data are also available for calculating the maximum twenty-four-hour and crest flows of the minor flood of April 6, 1926. In this flood, the crest flow was 31,000 second-feet, 37 per cent larger than the maximum mean daily flow of 22,700 second-feet and 24 per cent larger than the maximum twenty-hour flow of 25,000 second-feet. The maximum twenty-four-hour flow was 10.1 per cent larger than the maximum mean daily flow.

It is seen, therefore, from the data available that the crest flow is from 13 to 53 per cent larger than the maximum mean daily flow and from 17 to 24 per cent larger than the maximum twenty-four-hour flow. The maximum twenty-four-hour flow ranges from 10.1 to 23.3 per cent larger than the maximum mean daily flow.

It may be noted that seventeen of the twenty floods occurred in the months of January, February and March, with greater number in January and February and only one each in November, December and May. The flood in May, however, was one of the lesser floods and occurred with a relatively low precipitation. It resulted principally from the rapid melting of snow in the high altitudes, rather than high intensity of rainfall because relatively high flows continued for a month following the day of peak discharge accompanied by small amount of precipitation on the watershed. It would appear, therefore, that the months in which large floods would be more liable to occur would be from December to May.

The degree of normalcy of the season in precipitation at the time the floods occurred is given in the table, expressed in per cent of normal precipitation to same date. The minimum figure is 77 and the maximum 194. If the occurrences during the past 24 years are a criterion of what might be expected in the future, it is seen that, during the flood season, floods would not be expected to occur except when a substantial part of the normal rainfall to any date, has taken place.

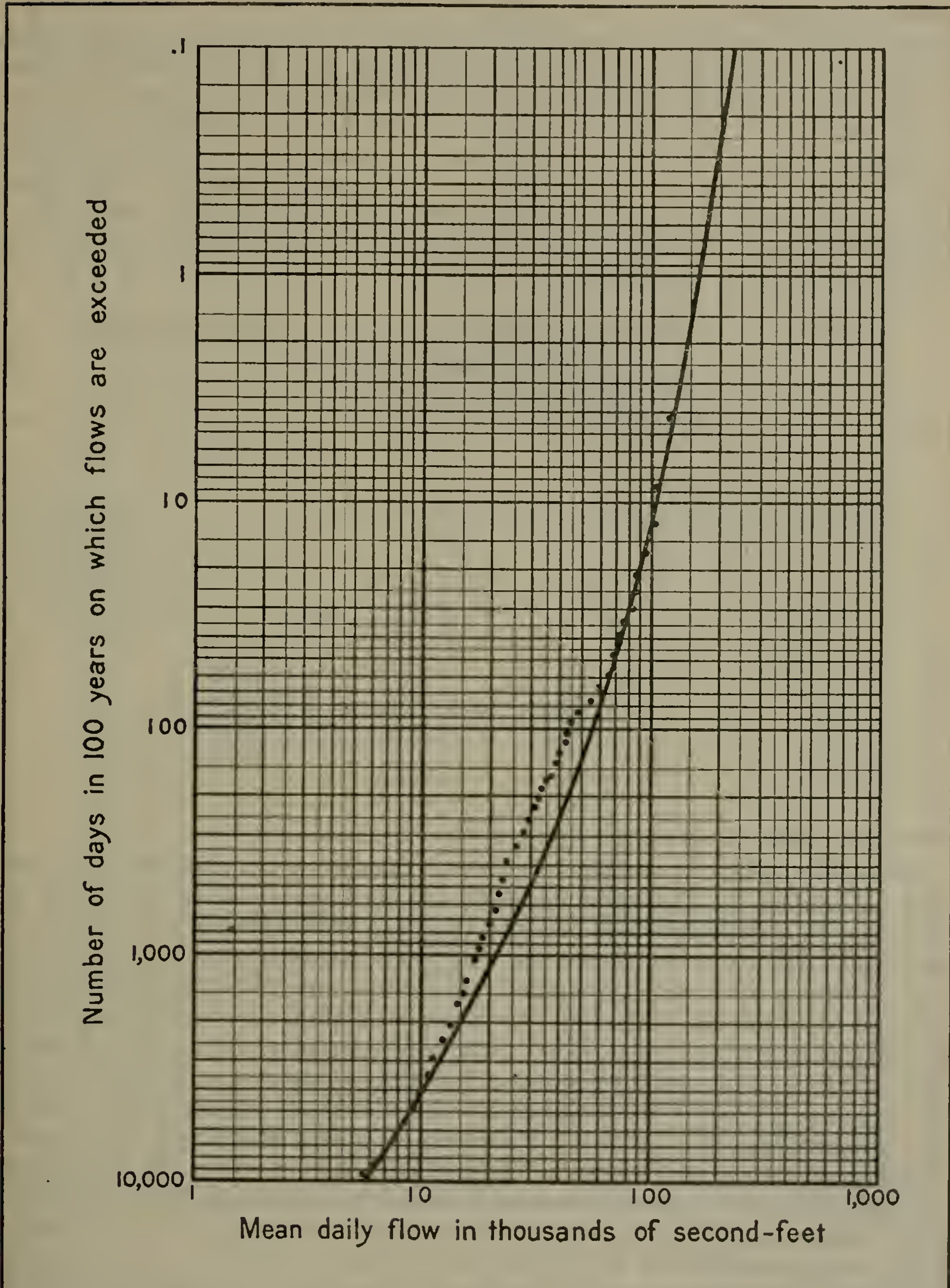
TABLE 44. TWENTY LARGEST FLOODS ON AMERICAN RIVER
Measured by United States Geological Survey at Fairoaks Gaging Station

Number	Date of flood	Maximum mean daily flow		Seasonal precipitation at United States Weather Bureau station at Folsom City, up to day before the flood	
		Second-feet	Inches depth on watershed in 24 hours	Inches	Per cent of normal to same date
1	March 25, 1928	120,000	2.33	15.68	77
2	March 19, 1907	105,000	2.03	31.26	159
3	January 14, 1909	98,000	1.90	10.66	102
4	February 2, 1907	80,800	1.57	21.12	156
5	January 31, 1911	69,100	1.34	25.37	194
6	February 6, 1925	68,200	1.32	14.19	101
7	January 21, 1909	62,500	1.21	16.18	139
8	January 1, 1914	57,700	1.12	9.99	119
9	January 26, 1914	52,600	1.02	20.74	167
10	February 21, 1927	48,200	.93	21.75	134
11	December 2, 1909	47,000	.91	5.20	124
12	February 11, 1919	45,000	.87	13.37	90
13	January 19, 1906	44,500	.86	11.24	99
14	February 21, 1914	42,600	.83	24.54	151
15	May 12, 1915	41,800	.81	29.02	123
16	November 21, 1909	40,800	.79	3.28	106
17	March 7, 1911	39,800	.77	33.54	184
18	February 25, 1917	37,600	.73	16.49	98
19	January 22, 1914	36,500	.71	17.91	152
20	March 24, 1906	34,000	.66	23.88	118

Frequency of flood occurrence.

Although Table 44 sets forth the largest floods that have occurred during the past twenty-four years, no adequate conception is gained of the size and frequency of floods which might be expected to occur in the future. In order that this may be had, Plate IV, "Probable Frequency of Flood Discharge on American River at Fairoaks," has been prepared similarly to Plate II, "Probable Frequency of Flood Discharge," in Bulletin No. 14. In the preparation of this plate, mean daily flows for each day whose mean exceeded 5000 second-feet were included in the data. Values were arranged and numbered in order of decreasing magnitude. The figure assigned to any particular flow indicated the number of days that size of flow was exceeded during the period of stream measurement. These figures were then expanded to values had the period of record been 100 years. Each figure represented the number of days in 100 years or frequency, which flows of a given size would be expected to be exceeded. The values of flood discharge were then plotted with their respective frequencies on a logarithmic scale. A smooth curve was drawn through the plotted points and extended beyond the data to a frequency of 0.1 day in 100 years or 1 day in 1000 years, in a manner that, it is believed, best interprets the plotted data. It is an empirical interpretation and the only assumption made is that whatever relation exists between size and frequency of occurrence of floods is contained in the period of stream measurement. It may be noted that, if the curve were extended beyond the limits of the graph, still larger values of flood discharge would be obtained but with less average frequencies. Therefore, while the curve indicates that a flood may occur which would be much larger than any of record, the probability of its occurrence is correspondingly less.

PLATE IV



PROBABLE FREQUENCY OF FLOOD DISCHARGE
ON AMERICAN RIVER AT FAIR OAKS

Values of maximum mean daily flood flow for several average frequencies with which values are exceeded were taken from the curve and listed in Table 45. They are expressed both in second-feet and inches depth of run-off in 24 hours from the drainage basin. The maximum mean daily flows vary from 56,000 second-feet, which may be expected to be exceeded with an average frequency of 100 days in 100 years or 1 day every year, to 230,000 second-feet, which may be expected to be exceeded with an average frequency of one day in 1000 years.

It may be noted that a flow that may be expected to be exceeded with an average frequency of one day in 100 years is almost three times larger than one that may be expected to be exceeded one day every year, and one that may be expected to be exceeded on the average of 1 day in 1000 years is four times larger.

TABLE 45. ESTIMATED FLOOD FLOW OF AMERICAN RIVER
At Fairoaks Gaging Station
(Values taken from Plate IV.)

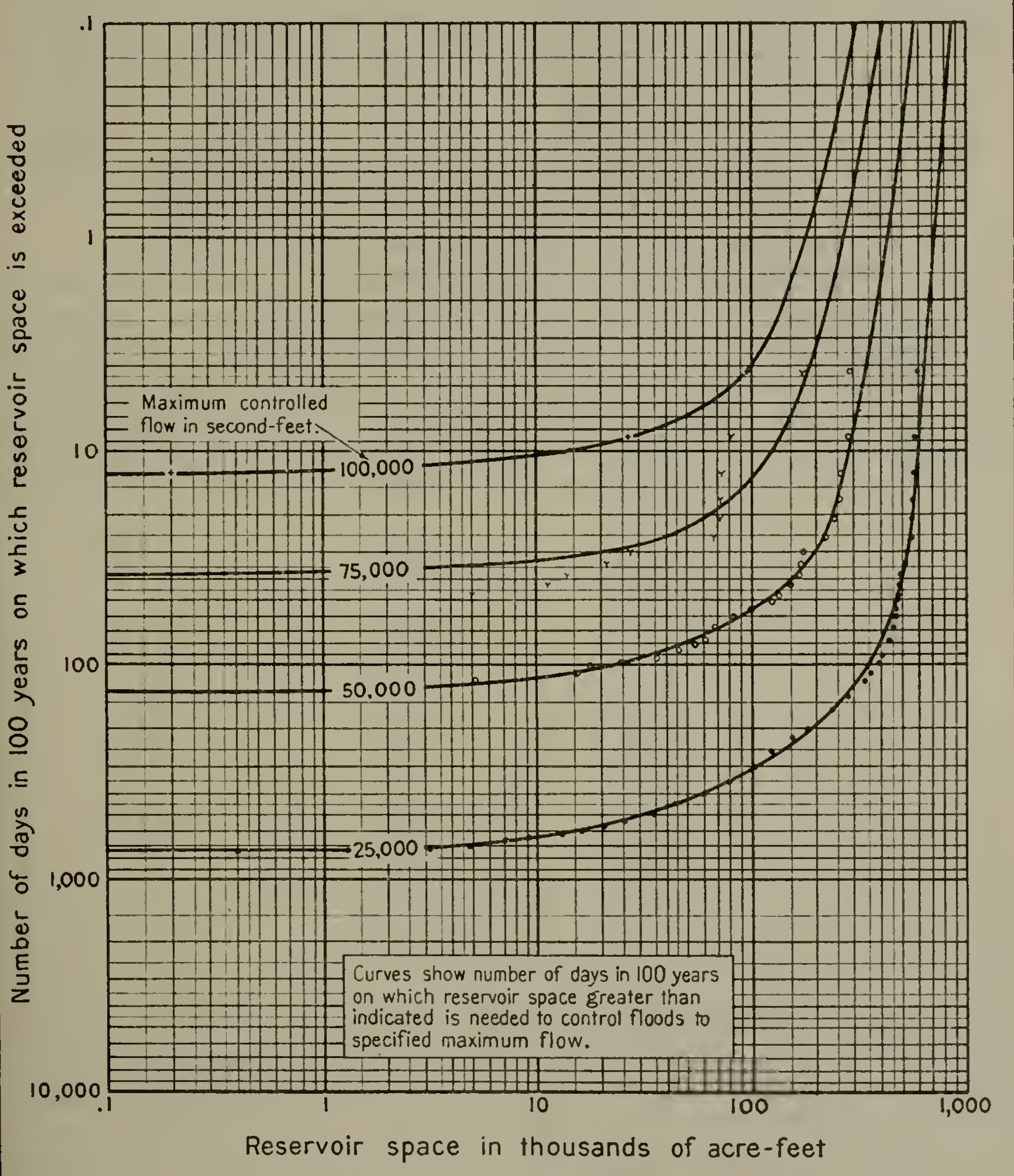
Average frequency with which values are exceeded, days in 100 years	Maximum mean daily flow	
	Second-feet	Inches depth in 24 hours on drainage basin (Area of drainage basin 1919 square miles)
100	56,000	1.1
10	104,000	2.0
4	126,000	2.4
2	144,000	2.8
1	162,000	3.1
0.1	230,000	4.5

Reservoir space required to control floods.

Reservoir space required to control floods on the American River was estimated by the same method of analysis as that described in Chapter IV, Bulletin No. 14. Space that would have to be held in reserve on each day to absorb the volume of run-off of the days following in excess of several specified maximum controlled flows was calculated for all mean daily flows in excess of 25,000 second-feet measured at the Fairoaks gaging station of the United States Geological Survey. The maximum controlled flows used in this analysis are 25,000, 50,000, 75,000 and 100,000 second-feet. These calculated values were used in the preparation of Plate V, "Reservoir Space Required to Control Floods on American River." They were listed in order of decreasing magnitude and numbered consecutively for each maximum controlled flow. Each number represented the number of days during the period of stream measurement that reservoir space in excess of the particular value was required to control floods to a specified maximum controlled flow. These numbers were expanded to represent the number of days, or frequency, had the period of stream measurement been 100 years in length. The values of reservoir space were plotted in accord with their respective frequencies on a logarithmic scale. Smooth curves were drawn through the points and extended to a frequency of 0.1 day in 100 years or 1 day in 1000 years for each maximum controlled flow, delineating the trend of the data. The curves for the larger controlled flows were shaped by the plotted data and also by comparison with those of the smaller controlled flows.

A value of reservoir space taken from a curve of a particular maximum controlled flow for a selected frequency is the space that would absorb the volume of run-off in excess of the specified maximum controlled flow except on the number of days in 100 years representing the selected frequency.

PLATE V



RESERVOIR SPACE REQUIRED TO CONTROL FLOODS ON AMERICAN RIVER

Controlled flow measured at Fair Oaks gaging station of United States Geological Survey

The values of reservoir space that would have to be held in reserve and the probable frequency with which the reservoirs would fill in controlling floods on the American River are taken from Plate V and are set forth in Table 46 for the several specified rates of maximum controlled flow.

TABLE 46. RESERVOIR SPACE REQUIRED TO CONTROL FLOODS ON AMERICAN RIVER

At Fairoaks gaging station

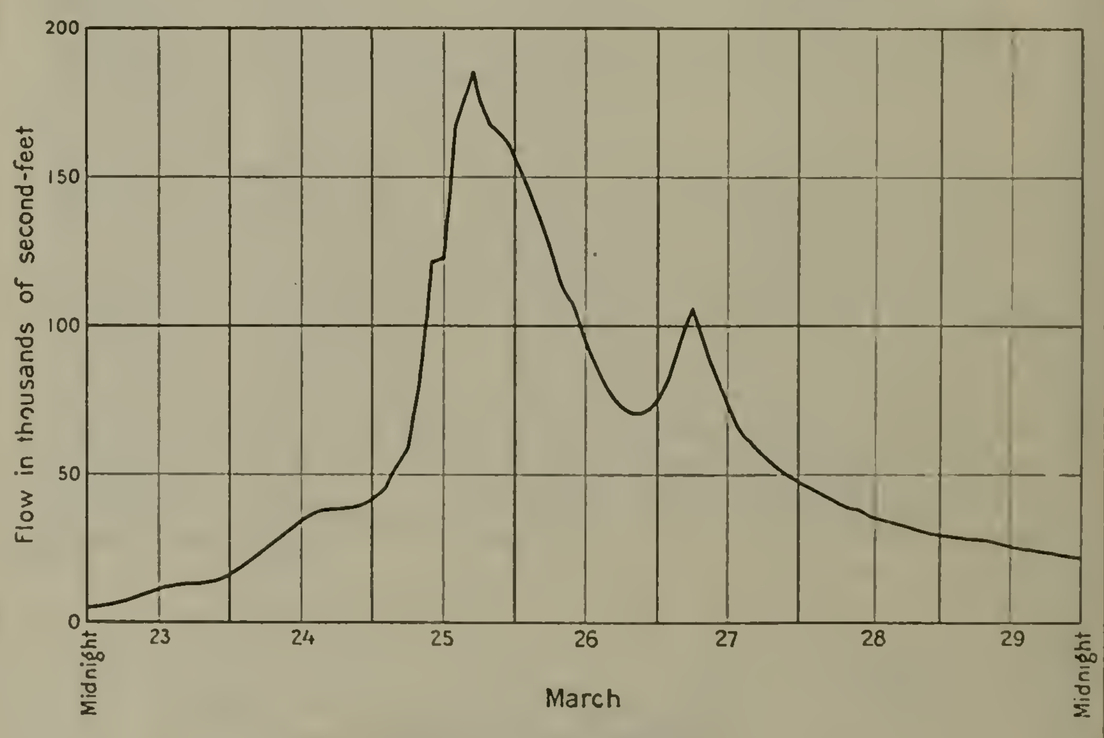
(Values taken from Plate V.)

Maximum controlled flow, in second-feet	Reservoir space, in acre-feet				
	Exceeded one day in 1000 years	Exceeded one day in 100 years	Exceeded one day in 50 years	Exceeded one day in 25 years	Exceeded one day in 10 years
25,000	850,000	720,000	680,000	640,000	600,000
50,000	570,000	430,000	380,000	310,000	285,000
75,000	410,000	270,000	235,000	190,000	125,000
100,000	310,000	175,000	140,000	100,000	15,000

Size of floods controllable with specified amounts of reservoir space.

While Table 46 sets forth the amount of reservoir space required for several maximum controlled flows with varying degrees of protection, no information is contained therein as to the magnitude of the flood that could be controlled for any particular amount of reservoir space. In order that this may be had, estimates were prepared for various amounts of reservoir space and values of maximum controlled flow. It was assumed in the estimates that the flow characteristics of a flood

PLATE VI



HYDROGRAPH OF FLOOD OF 1928
ON AMERICAN RIVER

Measurements at Fair Oaks gaging station of United States Geological Survey were the same as those of the March, 1928, flood, the largest of record. The flow characteristics of this flood from March 23–30 are delineated on Plate VI, "Hydrograph of Flood of 1928 on American River."

Table 47 sets forth, for amounts of reservoir space ranging from 100,000 to 500,000 acre-feet, the crest discharge of floods with flow characteristics of March, 1928, flood, which are controllable to various maximum controlled flows ranging from 50,000 to 125,000 second-feet. Values of crest discharge are given both in second-feet and in per cent of crest discharge of 1928 flood.

TABLE 47. SIZE OF FLOODS ON AMERICAN RIVER CONTROLLABLE WITH SPECIFIED AMOUNTS OF RESERVOIR SPACE ;
Characteristics of flow same as those of March, 1928 flood

Reservoir space, in acre-feet	Maximum controlled flow, in second-feet	Crest discharge of flood controllable	
		In second-feet	In per cent of crest discharge of March, 1928 flood
100,000	50,000	115,000	62
	75,000	150,000	82
	100,000	184,000	100
	125,000	225,000	122
200,000	50,000	155,000	84
	75,000	195,000	106
	100,000	235,000	128
	125,000	275,000	149
300,000	50,000	190,000	103
	75,000	230,000	125
	100,000	275,000	149
	125,000	315,000	171
400,000	50,000	220,000	120
	75,000	265,000	144
	100,000	310,000	168
	125,000	350,000	190
500,000	50,000	250,000	136
	75,000	300,000	163
	100,000	340,000	185
	125,000	380,000	206

Maximum storage reservation for flood control in reservoirs of consolidated development.

It is manifest that space available in any particular reservoir for flood control use is limited by its total capacity. If the reservoir is operated purely for flood control purposes, this total capacity determines the degree of flood control that can be obtained. The degree of flood control attained would vary with amount of reservoir capacity, contingent, however, upon its being located at strategic points for control of run-off of the watershed.

If the reservoir is to be operated for conservation purposes, coordinately with flood control, then only a part of the total capacity could be used for flood control without interference with its conservation values, and therefore a lesser degree of protection would be procured than if the total capacity were used entirely for flood control purposes. In this study, only a part of the total space in each of the major reservoirs has been assigned to flood control use, which would impair its conservation value to the smallest extent and still obtain a considerable degree of flood control. The maximum reservation for flood control, in acre-feet and in per cent of the total capacity, assigned to each of three major reservoirs—Folsom, Auburn and Coloma—together with the maximum draw-down for flood control in each reservoir, in feet and in per cent of maximum available power head, are given in Table 48. The maximum space assigned for flood control with the complete development is 500,000 acre-feet, 29.1 per cent of the total capacity of the reservoirs. The maximum draw-down for flood control in the reservoirs ranges from 18.4 per cent of the maximum power head at the Folsom reservoir to 6.1 per cent at the Coloma reservoir.

The size of floods controllable by the maximum storage reservation in the reservoirs for the three stages of development has been estimated for various maximum controlled flows, assuming that the flood would have the same flow characteristics as those of the flood of March, 1928. The data are given in Table 49. With 175,000 acre-feet in the Folsom reservoir reserved for flood control, a flood with a crest discharge of 225,000 second-feet could be controlled to 100,000 second-feet maximum flow; with a total maximum reservation of 375,000 acre-feet (175,000 acre-feet in Folsom and 200,000 acre-feet in Auburn reservoir), a flood with a crest discharge of 300,000 second-feet could be controlled to the same maximum flow; and with a total maximum reservation of 500,000 acre-feet (175,000 acre-feet in Folsom, 200,000 acre-feet in Auburn and 125,000 acre-feet in Coloma reservoir), a flood with a crest discharge of 340,000 second-feet could be controlled to the same maximum flow.

TABLE 48. MAXIMUM STORAGE RESERVATION FOR FLOOD CONTROL IN RESERVOIRS OF CONSOLIDATED DEVELOPMENT

Reservoir	Total capacity, in acre-feet	Maximum reservation for flood control		Maximum draw-down in reservoir for flood control	
		In acre-feet	In per cent of total capacity	In feet	In per cent of maximum power head
Folsom	355,000	175,000	49.3	35	18.4
Auburn	598,000	200,000	33.4	54	14.0
Coloma	766,000	125,000	16.3	20	6.1
Totals	1,719,000	500,000	29.1	....	....

TABLE 49. SIZE OF FLOODS CONTROLLABLE BY MAXIMUM STORAGE RESERVATION FOR FLOOD CONTROL ASSIGNED TO RESERVOIRS OF CONSOLIDATED DEVELOPMENT

Characteristics of flood flow same as those of March, 1928 flood

Maximum storage reservation:

Folsom reservoir	175,000 acre-feet
Auburn reservoir	200,000 acre-feet
Coloma reservoir	125,000 acre-feet
Total......	500,000 acre-feet

Stage of development	Maximum space reserved for flood control, in acre-feet	Maximum controlled flow, in second-feet	Crest discharge of flood controllable	
			In second-feet	In per cent of crest discharge of March, 1928 flood
Folsom reservoir..................................	175,000	75,000	184,000	100
		100,000	225,000	122
		125,000	265,000	144
Folsom and Auburn reservoirs......................	375,000	75,000	260,000	141
		100,000	300,000	163
		125,000	340,000	185
Folsom, Auburn and Coloma reservoirs.............	500,000	50,000	250,000	136
		75,000	300,000	163
		100,000	340,000	185
		125,000	380,000	206

Proposed method for operating reservoirs of consolidated development for flood control coordinately with conservation.

In evolving a rule for the operation of the reservoirs of the consolidated development for flood control coordinately with conservation uses, consideration has been given not only to the amount of reservoir space to be held in reserve but also to its needs as related to the time of year and the progressive rainfall index (ratio of actual precipitation up to any date in a season to the normal amount up to same date). The utility of various amounts of reservoir space for flood control has been set forth in the previous pages. The principles underlying the relations of time of year and of progressive rainfall index to need of reservoir space are discussed fully in Chapter IV, Bulletin No. 14. Analyses similar to those in that bulletin have been made to estimate the limiting dates in the season for the need of reservoir space and the values of progressive rainfall index with which no reservoir space is needed for various maximum controlled flows. Details of the analyses are omitted in this report. The results have been incorporated in the proposed rules for operating the reservoirs of the consolidated development.

The rule for operating the Folsom reservoir, constructed as a first unit of the consolidated plan of development for flood control coordinately with conservation uses, proposes that a maximum space of 175,000 acre-feet be held in reserve at times for the control of floods to 100,000 second-feet maximum flow measured at the Fairoaks gaging station. The rule is as follows:

> Some space would be held in reserve for flood control from December 1 to May 1 in each flood season whenever the total precipitation up to any date in the season is more than 50 per cent of the precipitation to the same date in a normal season. The flood control reserve would be increased at a uni-

> form rate from zero on December 1, the beginning of the flood season to the maximum of 175,000 acre-feet on January 1. This maximum space would be held in reserve from January 1 to April 1 and then decreased at a uniform rate to zero on May 1. This space would be maintained as nearly as possible without exceeding the maximum controlled flow of 100,000 second-feet measured at the Fairoaks gaging station of United States Geological Survey. Precipitation to be measured at the cooperative-rainfall station of the United States Weather Bureau at Folsom.

To control the floods in accordance with this rule, flood control works would be provided in the dam. These would consist of outlets through the dam, with control gates, placed at a depth below the crest which would insure a maximum controlled flow of 100,000 second-feet with the maximum storage reservation of 175,000 acre-feet. In addition to the flood control outlets, an overflow spillway with crest gates would also be provided for supplementary control.

With this provision in the Folsom reservoir for flood control, floods considerably larger than that of 1928, with the same flow characteristics, could be controlled, dependent, however, on dates of occurrences. A flood with a crest flow of 22 per cent greater than that of 1928 and with a volume in excess of the controlled flow of 100,000 second-feet 86 per cent greater than that of 1928, could be controlled during the period of maximum storage reservation for flood control, without exceeding the specified maximum controlled flow and without encroaching on the 5-foot freeboard of the dam.

If the water level in the reservoir were allowed to rise to the crest of the dam and the overflow spillway gates kept closed and the flood control outlets allowed to discharge 100,000 second-feet, a still larger flood could be controlled. In this instance, one with a crest flow 36 per cent larger than that of 1928 and with a volume in excess of the controlled flow of 100,000 second-feet 147 per cent greater than that of 1928 could be controlled with a maximum discharge for a short time 14 per cent above the specified controlled flow. This size of flood could reoccur at intervals of four days during the period of maximum reservation without failure in control.

If Auburn reservoir were constructed as a second unit to Folsom in the progressive development, space in it also could be reserved for flood control purposes in addition to that assigned to flood control in the Folsom reservoir. This additional space could be used for flood control, either in maintaining the same maximum controlled flow for larger floods, or to reduce flood flows to smaller controlled flows. In the first instance, the rule for operation would be identical to that given for the Folsom reservoir alone except that the amount of reservoir space would be increased. In this report, it is proposed that 200,000 acre-feet be the maximum space to be held in reserve for flood control in the Auburn reservoir in addition to the 175,000 acre-feet in the Folsom reservoir. It is estimated that this total amount of reservoir space could control a flood with a crest flow 63 per cent larger than that of 1928, and with a volume in excess of the controlled flow of 100,000 second-feet 286 per cent greater than that of 1928, during the period of maximum storage reservation for flood control, assuming that the flood had the same flow characteristics as that of 1928. If the water level in the reservoirs were allowed to rise to the crest of the dams and the overflow spillway gates were kept closed and the flood control outlets at Folsom were allowed to discharge 100,000 second-feet, a flood with a crest flow 77 per cent larger than that of 1928 and with a volume in excess of the controlled flow of 100,000 second-feet 363 per cent greater than that of 1928 could be controlled with a maximum discharge for a short time about 23 per cent greater than the specified maximum controlled flow of 100,000 second-feet. In the second instance, if the flood flows were to be reduced to a maximum controlled flow of 75,000 second-feet, utilizing the same amounts of reservoir space for flood control as in the first instance, the rule for operation would be changed slightly. The date of starting to prepare the reservoir for flood control would be November 1 instead of December 1. The space for flood control would be increased at a uniform rate from zero on November 1 to the maximum of 375,000 acre-feet on December 1, this amount being held in reserve until April 1, when it would be reduced at a uniform rate to zero on May 1. As in the first instance, space would be held in reserve for flood control during the flood season only when the precipitation up to any date in the season was more than 50 per cent of the precipitaton to the same date in a normal season. Operated in this manner, a flood with a crest flow 41 per cent larger than that of 1928 and with a volume in excess of the controlled flow of 75,000 second-feet 122 per cent larger than that of 1928 could be controlled without encroaching on the freeboard of the dams, assuming that the flood would have the same flow characteristics as those of the 1928 flood.

If the Coloma reservoir were constructed as the third major unit in the progressive development, space could also be reserved in it for flood control purposes in addition to the space assigned to the Folsom and Auburn reservoirs. This additional space could be used either to control larger floods to the maximum controlled flows (100,000 and 75,000 second-feet) as discussed previously for the Folsom and Auburn reservoirs or to reduce flood flows to a still smaller controlled flow. However, since the Coloma reservoir would probably be constructed as the last unit in the development and the flood channel in the lower American River would have already been constructed to a capacity of the larger controlled flows, it is not probable that the additional space for flood control in the Coloma reservoir would be used to reduce floods to a smaller controlled flow but rather to reduce larger floods to the maximum controlled flow for which the flood channel was built. It is proposed herein that 125,000 acre-feet of space be assigned for flood control in the Coloma reservoir, which, with the 175,000 acre-feet in the Folsom reservoir and 200,000 acre-feet in the Auburn reservoir, makes a total of 500,000 acre-feet of maximum storage reservation for flood control. If this total space were to be utilized to control floods to 100,000 second-feet maximum flow, measured at the Fairoaks gaging station, the rule for operation would be identical to that for the Folsom reservoir alone, except that the reservoir space would be increased from 175,000 acre-feet to 500,000 acre-feet. It is estimated that this total amount of reservoir space could control a flood with a crest flow 85 per cent larger than that of March, 1928, and with a volume in excess of 100,000 second-feet, 407 per cent greater than that of 1928, during the period of maximum storage reservation, assuming that the flood had the same flow characteristics as that of 1928.

If it were desirable to reduce floods to 75,000 second-feet, using the total reservation of 500,000 acre-feet for flood control in the three major reservoirs, the rule for operation would be the same as for the Folsom and Auburn reservoirs together operated for the control of floods to 75,000 second-feet, except that the value of reservoir space would be increased from 375,000 acre-feet to 500,000 acre-feet. It is estimated that this total amount of reservoir space could control a flood with a crest flow 63 per cent larger than that of March, 1928, and with a volume in excess of the maximum controlled flow of 75,000 second-feet, 192 per cent greater than that of 1928, during the period of maximum reservation for flood control, if the flood had the same characteristics as that of 1928.

Degree of protection afforded by supplementary reservoir control.

It has been pointed out previously in this chapter the size of floods on the American River that could be controlled to several maximum controlled flows utilizing certain assigned amounts of space in the reservoirs of the consolidated development. It is of interest to compare the degree of protection obtainable by reservoir control employed in conjunction with a leveed channel of adequate capacity with that provided by other plans that have been proposed for the control of floods on the lower American River.

The plan recommended by the California Debris Commission and adopted by the State Legislature provides for a leveed channel without upstream reservoir control. The channel would be formed by levees spaced 2400 feet apart, and would be capable of passing a flood flow of 128,000 second-feet with a clearance of three feet on the levees.

Another plan which has been given consideration is a modification of the above, in that higher levees, spaced 2400 feet, would be provided to pass a flood flow of 180,000 second-feet with a clearance of 3 feet on the levees.

With supplementary reservoir control, the plans set forth above would be modified to the extent that the width of the flood channel would be materially reduced, because of the lesser flood flow. If 175,000 acre-feet of space in the Folsom reservoir were utilized for flood control purposes, a flood with a crest flow of 225,000 second-feet and flow characteristics of the March, 1928, flood, could be controlled to 100,000 second-feet, maximum flow, without encroaching on the freeboard of the dam or levees, which could be confined to a flood channel formed by levees spaced at about one-half the distance proposed in the plans without supplementary reservoir control. If the level of the reservoir were allowed to rise to the crest of the dam, utilizing 34,000 acre-feet of additional space, a flood with a crest flow of 240,000 second-feet and with characteristics of the March, 1928, flood, could be controlled to 100,000 second-feet and one with a crest of 250,000 second-feet and with the same characteristics could be controlled to 115,000 second-feet.

It is apparent, therefore, by reserving 175,000 acre-feet of space for flood control in the Folsom reservoir and providing adequate flood control works in the dam to insure a discharge of 100,000 second-feet and a leveed channel of adequate capacity on the lower American River, greater protection would be afforded the overflow area than with either of the plans without reservoir control outlined above. If space were reserved for flood control in the Auburn and Coloma reservoirs, in addition to the 175,000 acre-feet in the Folsom reservoir and adequate flood control works provided in the dams, a still greater degree of protection would be obtained utilizing the same flood channel as with Folsom alone; either a flood with a greater crest flow than 225,000 second-feet (flow characteristics of March, 1928, flood) could be reduced to a maximum controlled flow of 100,000 second-feet or a flood with a crest flow of 225,000 second-feet (flow characteristics of March 1928, flood) could be reduced to a maximum controlled flow less than 100,000 second-feet. Furthermore, by reducing the flood flow in the American River, the safety of the levee system of the Sacramento River, downstream from the mouth of the American River, would be materially increased.

Interference of flood control with conservation values of reservoirs of consolidated development.

The effect of the inclusion of flood control in the operation of the reservoirs of the consolidated development on their yield in power and water has been estimated for the three stages of development for the period, 1905–1927. The estimates were based on controlling floods to 100,000 second-feet maximum flow measured at the Fairoaks gaging station of the United States Geological Survey and employing the assigned amounts of maximum space for flood control in the reservoirs set forth in Table 48, which are as follows: Folsom, 175,000 acre-feet; Auburn, 200,000 acre-feet; and Coloma, 125,000 acre-feet, a total of 500,000 acre-feet. The reservoirs were operated in accord with the rule for the Folsom reservoir set forth previously in this chapter, except that the value of the maximum reservation for flood control would be increased from 175,000 acre-feet for the initial development with Folsom reservoir alone; to 375,000 acre-feet for the second stage of development with Folsom and Auburn reservoirs; to 500,000 acre-feet for the third stage or complete development with Folsom, Auburn and Coloma reservoirs operated for flood control. Space was held in reserve for flood control from December 1 to May 1 in each flood season when the precipitation on any date was more than 50 per cent of the normal precipitation to the same date, calculated from rainfall records at the cooperative rainfall station of United States Weather Bureau at Folsom City. The space held in reserve for flood control was increased at a uniform rate from zero on December 1 to the maximum reservation on January 1 and the maximum held from January 1 to April 1 from which date it was decreased at a uniform rate to zero on May 1.

In estimating the effect of flood control on the power output of the plants for various methods of water release and stages of development, the same generating equipment was assumed for both with and without flood control. Estimates were made to determine the interference, if any, of the various combinations but only one detailed study was made. This was on the Folsom reservoir constructed as a first unit and operated primarily for power generation with water release in accord with the schedule proposed by the American River Hydro-electric Company. The plant layout was taken as that proposed by the American River Hydro-electric Company, consisting of two units, one unit discharging into the Folsom Canal at tailrace elevation 207.0 feet and the second unit discharging into the American River below the present Folsom Prison dam at elevation 162 feet. The computations were carried out on a daily basis, using the measured daily flows of the

American River at the Fairoaks gaging station of the United States Geological Survey for the period 1905–1927. The installed capacity of the power plant was 35,000 k.v.a. P.F.=0.80, operated on a 100 per cent load factor. The results of the computations are summarized in Tables 50 and 51. Table 50 sets forth, by years, the measured run-off at Fairoaks, stage of the reservoir at the beginning of the year, power draft through the turbines for each unit, evaporation on the reservoir surface, waste over the spillway, and average power head and power output for each unit and the total output with the reservoir operated without flood control and similar data with the reservoir operated coordinately with flood control in accord with the rule given above for the Folsom reservoir. Estimating on a daily basis, the same power output was maintained on each day throughout the period 1905–1927 with and without flood control. This was accomplished by passing additional water through the turbines to compensate for the reduction of power head with flood control. This would necessitate increasing the size of the penstocks and the water capacity of the turbines which has been done in preparing the cost estimates given in Chapter IX. The table shows the average annual power output for the period 1905–1927 with flood control was slightly greater (900,000 kilowatt hours) than without flood control. Without flood control, an average of 1,684,600 acre-feet would have wasted over the spillway annually, whereas with flood control this would have been 715,800 acre-feet, the difference being accounted for by 917,000 acre-feet being released through the flood control outlets, 52,500 acre-feet additional being passed through the turbines to compensate for the reduced power head and 700 acre-feet less evaporation from the reservoir surface. Table 51 sets forth the monthly data for the period 1905–1927, summarized in Table 50, by years.

Other estimates of the interference on the power output of the inclusion of the flood control features for the other stages of development have been made, based, however, on monthly averages of run-off used in the power studies summarized in Chapter IV, because values of daily run-off at the Coloma and Auburn dam sites were not available. These estimates are necessarily only approximate. However, they are probably as accurate as the estimates of water and power yield without flood control, based on average monthly quantities. The results are summarized in Tables 52 and 53, for the three stages of development. Table 52 gives the average annual power output with and without flood control and the loss in total power output due to the inclusion of flood control with the method of water release from the reservoirs to develop maximum primary power. Table 53 gives similar information with the schedule of water release proposed by the American River Hydro-electric Company. It may be noted that the greatest loss in power output is 1.2 per cent for the complete development with water released from the reservoirs in accord with schedule proposed by the American River Hydro-electric Company.

The effect of flood control on the yield of the reservoirs in irrigation supply for the three stages of development has also been estimated, employing the same rules as those used with the reservoirs operated primarily for power generation. In this instance, however, no study was made on a daily basis, only average estimated monthly values of run-off being used. It was assumed in the estimates that the operation of the existing Folsom City plant of the Pacific Gas and Electric Company would be subordinated to that of the consolidated development, and that no water would be released especially to meet the requirements of this plant. Data are given in Table 54 showing the effect of the inclusion of the flood control feature in the reservoirs on the yield in irrigation draft. The seasonal irrigation yield is the same for each of the three stages of development both with and without flood control. However, the deficiencies in supply are different with flood control in the second and third stages of development. In the second stage, a deficiency of 1.0 per cent occurs in 1908, in addition to those in 1924 and 1926, which remain the same, 40.0 and 7.7 per cent, respectively, of a perfect seasonal supply with and without flood control. In the third stage, or complete development, additional deficiencies occur in four other years with an average seasonal deficiency in supply of 3.2 per cent of a perfect seasonal supply for the period 1905–1927 with flood control, compared to 2.2 per cent without flood control. However, the deficiency in 1924, the year of largest deficiency, remains the same, 41.3 per cent with and without flood control.

Water release for power generation in accord with schedule proposed by American River Hydro-electric Company

Installed capacity of power plant, 35,000 k.v.a. P.F.=0.80 L.F.=1.00

With Flood Control

00,000 second-feet. Maximum reservoir space required 175,000 acre-feet. Reservoir space held in reserve for flood control from
ation up to any date in a season is more than 50 per cent of the normal precipitation to same date. Flood control reserve increased
er 1 to 175,000 acre-feet on January 1; 175,000 acre-feet held in reserve from January 1 to April 1 and then decreased at uniform

Evaporation in acre-feet	Release through flood control outlets in acre-feet	Waste over spillway in acre-feet	Average power head in feet		Power yield in kilowatt hours		
			Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Total
15,900	370,100	314,600	131.5	186.5	67,700,000	86,200,000	153,900,000
19,300	1,526,000	1,896,000	149.0	199.0	84,900,000	108,500,000	193,400,000
19,900	2,786,800	1,376,700	158.5	203.5	93,400,000	118,600,000	212,000,000
16,000	7,500	149,300	131.0	186.0	68,600,000	86,400,000	155,000,000
18,000	2,737,700	833,900	152.5	200.5	90,100,000	112,700,000	202,800,000
15,200	1,347,900	401,400	133.5	194.5	75,500,000	92,300,000	167,800,000
18,100	2,284,300	1,783,100	141.5	198.5	79,100,000	97,200,000	176,300,000
13,400	0	190,200	110.5	168.5	55,100,000	67,400,000	122,500,000
14,300	0	278,000	112.0	172.5	56,400,000	67,100,000	123,500,000
17,700	1,682,100	886,900	142.5	201.5	81,700,000	99,500,000	181,200,000
17,600	576,000	1,199,400	135.0	194.0	75,100,000	91,700,000	166,800,000
17,700	1,690,600	775,600	142.0	192.5	82,700,000	104,100,000	186,800,000
17,500	518,900	928,300	130.0	189.0	69,700,000	85,800,000	155,500,000
14,900	195,000	206,000	118.0	185.5	61,100,000	69,800,000	130,900,000
14,500	517,000	483,600	121.5	194.0	60,500,000	72,900,000	133,400,000
15,300	82,800	365,600	124.0	189.0	65,000,000	77,200,000	142,200,000
17,100	1,017,400	653,100	140.5	192.0	81,000,000	101,100,000	182,100,000
17,300	625,600	1,455,400	140.5	191.5	80,300,000	101,400,000	181,700,000
17,500	490,000	653,500	142.0	200.5	81,000,000	99,200,000	180,200,000
3,100	0	0	72.0	123.5	22,400,000	18,900,000	41,300,000
16,900	790,200	613,300	132.5	190.0	73,000,000	91,100,000	164,100,000
13,400	211,400	75,000	126.5	189.5	65,100,000	81,700,000	146,800,000
16,200	1,404,500	765,600	162.0	207.0	72,600,000	91,500,000	164,100,000
366,800	20,861,800	16,284,500	....	....	1,642,000,000	2,022,300,000	3,664,300,000
16,100	917,000	715,800	....	....	72,200,000	88,900,000	161,100,000

TABLE 50. POWER OUTPUT OF FOLSOM PLANT WITH AND WITHOUT FLOOD CONTROL

Folsom reservoir operated primarily for power generation
Auburn and Coloma reservoirs not constructed

Yearly Summary of Computations Carried out on a Daily Basis
(For corresponding monthly summary, see Table 51)

Measured daily flows at Fairoaks gaging station of United States Geological Survey used in computations

Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet

Water release for power generation in accord with schedule proposed by American River Hydro-electric Company
Installed capacity of power plant, 35,000 k.v.a. P.F.=0.80 L.F.=1.00

Without Flood Control

Year	Measured run-off at Fairoaks in acre-feet	Stage of reservoir at beginning of year in acre-feet	Power draft through turbines in acre-feet: Upper unit, tailrace elevation 207 feet	Power draft through turbines in acre-feet: Lower unit, tailrace elevation 162 feet	Evaporation in acre-feet	Waste over spillway in acre-feet	Average power head in feet: Upper unit, tailrace elevation 207 feet	Average power head in feet: Lower unit, tailrace elevation 162 feet	Power yield in kilowatt hours: Upper unit, tailrace elevation 207 feet	Power yield in kilowatt hours: Lower unit, tailrace elevation 162 feet	Power yield in kilowatt hours: Total
1905	1,881,400	25,000	577,700	557,800	16,800	729,100	135.0	191.0	66,800,000	85,200,000	152,000,000
1906	5,020,000	25,000	682,400	676,100	20,200	3,492,400	157.0	207.5	84,800,000	108,400,000	193,200,000
1907	5,620,400	173,900	724,000	724,000	20,800	4,247,200	166.0	211.0	92,200,000	117,500,000	209,700,000
1908	1,339,500	78,300	619,900	578,300	16,300	178,300	131.5	186.5	67,500,000	85,400,000	152,900,000
1909	5,240,700	25,000	716,500	693,600	18,900	3,485,500	162.5	210.5	90,000,000	112,700,000	202,700,000
1910	2,916,700	351,200	644,100	577,900	16,100	2,004,800	143.5	207.0	75,500,000	92,300,000	167,800,000
1911	5,398,100	25,000	643,700	595,200	19,000	4,140,200	150.5	207 5	78,800,000	96,900,000	175,700,000
1912	1,331,400	25,000	618,000	509,800	13,400	190,200	110.5	168.5	55,100,000	67,400,000	122,500,000
1913	1,464,500	25,000	608,400	488,100	14,300	278,000	112.0	172.5	56,400,000	67,100,000	123,500,000
1914	3,861,500	100,700	662,400	602,700	18,600	2,653,500	152.5	213.0	81,600,000	99,300,000	180,900,000
1915	3,093,300	25,000	659,000	588,300	18,500	1,827,500	140 5	201 0	74,800,000	91,400,000	166,200,000
1916	3,929,500	25,000	701,200	668,400	18,600	2,537,200	150.0	201.0	82,300,000	103,800,000	186,100,000
1917	2,684,500	29,100	623,200	560,000	18,400	1,487,000	135.5	194.5	69,600,000	85,600,000	155,200,000
1918	1,519,800	25,000	615,100	471,500	15,300	417,900	119.5	187.5	60,800,000	69,600,000	130,400,000
1919	2,061,800	25,000	535,700	461,600	15,300	1,049,200	126.0	201.0	59,900,000	72,300,000	132,200,000
1920	1,789,000	25,000	640,700	524,700	15,300	391,700	124.0	189.5	64,700,000	76,900,000	141,600,000
1921	2,971,100	241,600	680,800	636,300	18,000	1,816,600	150.0	202.5	80,800,000	100,900,000	181,700,000
1922	3,630,800	61,000	699,500	662,000	18,200	1,997,800	145.5	197.0	79,800,000	100,800,000	180,600,000
1923	2,355,700	314,300	659,700	604,800	18,400	1,362,100	152.0	212.5	81,000,000	99,200,000	180,200,000
1924	604,700	25,000	386,200	197,000	3,100	0	72 0	123.5	22,400,000	18,900,000	41,300,000
1925	2,700,600	43,400	649,600	593,200	17,800	1,458,400	139.0	197.0	72,800,000	90,900,000	163,700,000
1926	1,592,700	25,000	582,300	535,500	13,800	327,300	128.0	192.0	63,300,000	79,800,000	143,100,000
1927	3,293,100	158,800	541,500	541,500	17,100	2,251,800	172.5	217.5	71,400,000	90,400,000	161,800,000
Total for 1905-27	66,300,800	....	14,471,600	13,048,300	382,200	38,323,700	....	....	1,632,300,000	2,012,700,000	3,645,000,000
Average for 1905-27	2,914,300	....	636,100	573,600	16,800	1,684,600	....	....	71,700,000	88,500,000	160,200,000

With Flood Control

Maximum controlled flow at Fairoaks 100,000 second-feet. Maximum reservoir space required 175,000 acre-feet. Reservoir space held in reserve for flood control from December 1 to May 1 when total precipitation up to any date in a season is more than 50 per cent of the normal precipitation to same date. Flood control reserve increased at a uniform rate from zero on December 1 to 175,000 acre-feet on January 1; 175,000 acre-feet held in reserve from January 1 to April 1 and then decreased at uniform rate to zero on May 1

Year	Stage of reservoir at beginning of year in acre-feet	Power draft through turbines in acre-feet: Upper unit, tailrace elevation 207 feet	Power draft through turbines in acre-feet: Lower unit, tailrace elevation 162 feet	Evaporation in acre-feet	Release through flood control outlets in acre-feet	Waste over spillway in acre-feet	Average power head in feet: Upper unit, tailrace elevation 207 feet	Average power head in feet: Lower unit, tailrace elevation 162 feet	Power yield in kilowatt hours: Upper unit, tailrace elevation 207 feet	Power yield in kilowatt hours: Lower unit, tailrace elevation 162 feet	Power yield in kilowatt hours: Total
1905	25,000	603,300	577,500	15,900	370,100	314,600	131.5	186.5	67,700,000	86,200,000	153,900,000
1906	25,000	723,000	706,800	19,300	1,526,000	1,896,000	149.0	199.0	84,900,000	108,500,000	193,400,000
1907	173,900	772,300	760,300	19,900	2,786,800	1,376,700	158.5	203.5	93,400,000	118,600,000	212,000,000
1908	78,300	632,300	587,700	16,000	7,500	149,300	131.0	186.0	68,600,000	86,400,000	155,000,000
1909	25,000	765,500	730,600	18,000	2,737,700	833,900	152.5	200.5	90,100,000	112,700,000	202,800,000
1910	180,000	692,700	614,500	15,200	1,347,900	401,400	133.5	194.5	75,500,000	92,300,000	167,800,000
1911	25,000	685,800	626,800	18,100	2,284,300	1,783,100	141.5	198.5	79,100,000	97,200,000	176,300,000
1912	25,000	618,000	509,800	13,400	0	190,200	110.5	168.5	55,100,000	67,400,000	122,500,000
1913	25,000	608,400	488,100	14,300	0	278,000	112.0	172.5	56,400,000	67,100,000	123,500,000
1914	100,700	711,200	639,300	17,700	1,682,100	886,900	142.5	201.5	81,700,000	99,500,000	181,200,000
1915	25,000	689,300	611,000	17,600	576,000	1,199,400	135.0	194.0	75,100,000	91,700,000	166,800,000
1916	25,000	742,200	699,300	17,700	1,690,600	775,600	142.0	192.5	82,700,000	104,100,000	186,800,000
1917	29,100	646,400	577,500	17,500	518,900	928,300	130.0	189.0	69,700,000	85,800,000	155,500,000
1918	25,000	624,900	479,000	14,900	195,000	206,000	118.0	185.5	61,100,000	69,800,000	130,900,000
1919	25,000	563,800	482,900	14,500	517,000	483,600	121.5	194.0	60,500,000	72,900,000	133,400,000
1920	25,000	643,400	526,900	15,300	82,800	365,600	124.0	189.0	65,000,000	77,200,000	142,200,000
1921	180,000	729,400	673,100	17,100	1,017,400	653,100	140.5	192.0	81,000,000	101,100,000	182,100,000
1922	61,000	729,000	684,500	17,300	625,600	1,455,400	140.5	191.5	80,300,000	101,400,000	181,700,000
1923	180,000	708,200	641,500	17,500	490,000	653,500	142.0	200.5	81,000,000	99,200,000	180,200,000
1924	25,000	386,200	197,000	3,100	0	0	72.0	123.5	22,400,000	18,900,000	41,300,000
1925	43,400	681,400	617,200	16,900	790,200	613,300	132.5	190.0	73,000,000	91,100,000	164,100,000
1926	25,000	605,700	553,4[illegible]0	13,400	211,400	75,000	126 5	189.5	65,100,000	81,700,000	146,800,000
1927	158,800	588,700	576,9[illegible]0	16,200	1,404,500	765,600	162.0	207.0	72,600,000	91,500,000	164,100,000
Total for 1905-27	....	15,151,100	13,561,[illegible]	366,800	20,861,800	16,284,500	....	....	1,642,000,000	2,022,300,000	3,664,300,000
Average for 1905-27	....	666,000	596,1[illegible]	16,100	917,000	715,800	....	....	72,200,000	88,900,000	161,100,000

Water release for power generation in accord with schedule proposed by American River Hydro-electric Company

Installed capacity of power plant, 35,000 k.v.a. P.F. = 0.80 L.F. = 1.00

With Flood Control

cond-feet. Maximum reservoir space required 175,000 acre-feet. Reservoir space held in reserve for flood control from
any date in a season is more than 50 per cent of the normal precipitation to same date. Flood control reserve increased
,000 acre-feet on January 1; 175,000 acre-feet held in reserve from January 1 to April 1 and then decreased at uniform

oration re-feet	Release through flood control outlets in acre-feet	Waste over spillway in acre-feet	Average power head in feet		Power yield in kilowatt hours		
			Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Total
0	0	0	96.5	141.5	4,500,000	6,700,000	11,200,000
0	37,700	0	143.0	188.0	6,700,000	8,600,000	15,300,000
0	229,200	0	148.0	193.0	8,600,000	10,800,000	19,400,000
1,100	103,200	0	166.5	211.5	8,400,000	10,400,000	18,800,000
2,800	0	250,300	183.0	228.0	8,600,000	10,800,000	19,400,000
3,400	0	64,300	183.0	228.0	8,400,000	10,400,000	18,800,000
3,900	0	0	174.5	219.5	8,200,000	10,400,000	18,600,000
2,800	0	0	153.5	198.5	7,300,000	9,400,000	16,700,000
1,300	0	0	112.5	157.5	5,100,000	7,200,000	12,300,000
400	0	0	79.0	124.0	500,000	1,200,000	1,700,000
200	0	0	69.0	115.5	600,000	300,000	900,000
0	0	0	68.0	....	800,000	0	800,000
15,900	370,100	314,600	....	....	67,700,000	86,200,000	153,900,000
0	196,000	0	109.0	180.0	5,100,000	6,000,000	11,100,000
0	194,700	0	147.5	192.5	7,800,000	9,700,000	17,500,000
0	721,200	0	148.0	193.0	8,600,000	10,800,000	19,400,000
1,100	414,100	0	167.0	212.0	8,400,000	10,400,000	18,800,000
2,800	0	801,400	183.0	228.0	8,600,000	10,800,000	19,400,000
3,400	0	832,100	183.0	228.0	8,400,000	10,400,000	18,800,000
4,000	0	262,500	183.0	228.0	8,600,000	10,800,000	19,400,000
3,800	0	0	178.0	223.0	8,400,000	10,600,000	19,000,000
2,400	0	0	162.5	207.5	7,400,000	9,500,000	16,900,000
1,300	0	0	133.0	178.0	6,300,000	8,400,000	14,700,000
500	0	0	94.5	140.5	3,100,000	5,900,000	9,000,000
0	0	0	99.0	155.0	4,200,000	5,200,000	9,400,000
19,300	1,526,000	1,896,000	....	....	84,900,000	108,500,000	193,400,000
0	101,200	0	148.0	193.0	8,600,000	10,700,000	19,300,000
0	690,000	0	148.0	193.0	7,800,000	9,700,000	17,500,000
0	1,370,500	0	148.0	193.0	8,600,000	10,800,000	19,400,000
1,100	625,100	0	167.0	212.0	8,400,000	10,400,000	18,800,000
2,800	0	623,900	183.0	228.0	8,600,000	10,800,000	19,400,000
3,400	0	538,500	183.0	228.0	8,400,000	10,400,000	18,800,000
4,000	0	211,400	183.0	228.0	8,600,000	10,800,000	19,400,000
3,800	0	2,900	181.0	226.0	8,500,000	10,700,000	19,200,000
2,600	0	0	170.0	215.0	7,800,000	9,800,000	17,600,000
1,500	0	0	153.0	198.0	7,200,000	9,400,000	16,600,000
700	0	0	129.5	174.5	5,900,000	8,000,000	13,900,000
0	0	0	106.0	151.0	5,000,000	7,100,000	12,100,000
19,900	2,786,800	1,376,700	....	....	93,400,000	118,600,000	212,000,000
0	0	0	117.5	162.5	5,500,000	7,700,000	13,200,000
0	0	0	125.5	170.5	5,600,000	7,500,000	13,100,000
0	7,500	0	136.5	181.5	6,800,000	8,900,000	15,700,000
1,100	0	0	159.0	204.0	8,400,000	10,400,000	18,800,000
2,500	0	111,900	182.0	227.0	8,600,000	10,800,000	19,400,000
3,400	0	37,400	183.0	228.0	8,400,000	10,400,000	18,800,000
3,900	0	0	176.0	221.0	8,300,000	10,500,000	18,800,000
3,000	0	0	156.5	201.5	7,400,000	9,500,000	16,900,000
1,500	0	0	117.0	162.0	5,400,000	7,400,000	12,800,000
400	0	0	80.5	126.0	1,300,000	2,300,000	3,600,000
200	0	0	68.5	114.0	1,300,000	400,000	1,700,000
0	0	0	68.0	113.0	1,600,000	600,000	2,200,000
16,000	7,500	149,300	....	....	68,600,000	86,400,000	155,000,000

TABLE 51. POWER OUTPUT OF FOLSOM PLANT WITH AND WITHOUT FLOOD CONTROL

Folsom reservoir operated primarily for power generation
Auburn and Coloma reservoirs not constructed

Monthly Summary of Computations Carried out on a Daily Basis
(For corresponding yearly summary, see Table 50)

Measured daily flows at Fairoaks gaging station of United States Geological Survey used in computations

Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet

Water release for power generation in accord with schedule proposed by American River Hydro-electric Company
Installed capacity of power plant, 35,000 k.v.a. P.F.=0.80 L.F.=1.00

Year and Month	Measured run-off at Fairoaks in acre-feet	Without Flood Control										With Flood Control — Maximum controlled flow at Fairoaks 100,000 second-feet. Maximum reservoir space required 175,000 acre-feet. Reservoir space held in reserve for flood control from December 1 to May 1 when total precipitation up to any date in a season is more than 50 per cent of the normal precipitation to same date. Flood control reserve increased at a uniform rate from zero on December 1 to 175,000 acre-feet on January 1; 175,000 acre-feet held in reserve from January 1 to April 1 and then decreased at uniform rate to zero on May 1										
		Stage of reservoir at beginning of month in acre-feet	Power draft through turbines in acre-feet		Evaporation in acre-feet	Waste over spillway in acre-feet	Average power head in feet		Power yield in kilowatt hours			Stage of reservoir at beginning of month in acre-feet	Power draft through turbines in acre-feet		Evaporation in acre-feet	Release through flood control outlets in acre-feet	Waste over spillway in acre-feet	Average power head in feet		Power yield in kilowatt hours		
			Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet			Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Total		Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet				Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Total
1905—																						
January	200,800	25,000	61,500	61,500	0	0	96.5	141.5	4,500,000	6,700,000	11,200,000	25,000	61,500	61,500	0	0	0	96.5	141.5	4,500,000	6,700,000	11,200,000
February	234,700	102,800	55,500	55,500	0	0	145.5	190.5	6,200,000	8,100,000	14,300,000	102,800	60,400	59,400	0	37,700	0	143.0	188.0	6,700,000	8,600,000	15,300,000
March	378,000	226,500	61,500	61,500	0	126,500	173.0	218.0	8,200,000	10,300,000	18,500,000	180,000	76,200	72,600	0	229,200	0	148.0	193.0	8,600,000	10,800,000	19,400,000
April	409,000	355,000	59,500	59,500	2,000	288,000	183.0	228.0	8,400,000	10,400,000	18,800,000	180,000	65,500	64,200	1,100	103,200	0	166.5	211.5	8,400,000	10,400,000	18,800,000
May	376,100	355,000	61,500	61,500	2,800	250,300	183.0	228.0	8,600,000	10,800,000	19,400,000	355,000	61,500	61,500	2,800	0	250,300	183.0	228.0	8,600,000	10,800,000	19,400,000
June	179,100	355,000	59,500	59,500	3,400	64,300	183.0	228.0	8,400,000	10,400,000	18,800,000	355,000	59,500	59,500	3,400	0	64,300	183.0	228.0	8,400,000	10,400,000	18,800,000
July	42,700	347,400	61,500	61,500	3,900	0	174.5	219.5	8,200,000	10,400,000	18,600,000	347,400	61,500	61,500	3,900	0	0	174.5	219.5	8,200,000	10,400,000	18,600,000
August	16,600	263,200	61,500	61,500	2,800	0	153.5	198.5	7,300,000	9,400,000	16,700,000	263,200	61,500	61,500	2,800	0	0	153.5	198.5	7,300,000	9,400,000	16,700,000
September	8,200	154,000	59,500	59,500	1,300	0	112.5	157.5	5,100,000	7,200,000	12,300,000	154,000	59,500	59,500	1,300	0	0	112.5	157.5	5,100,000	7,200,000	12,300,000
October	9,100	41,900	9,100	12,500	400	0	79.0	124.0	500,000	1,200,000	1,700,000	41,900	9,100	12,500	400	0	0	79.0	124.0	500,000	1,200,000	1,700,000
November	11,500	29,000	11,500	3,800	200	0	69.0	115.5	600,000	300,000	900,000	29,000	11,500	3,800	200	0	0	69.0	115.5	600,000	300,000	900,000
December	15,600	25,000	15,600	0	0	0	68.0	......	800,000	0	800,000	25,000	15,600	0	0	0	0	68.0	......	800,000	0	800,000
Totals	1,881,400	....	577,700	557,800	16,800	729,100	....	....	66,800,000	85,200,000	152,000,000	....	603,300	577,500	15,900	370,100	314,600	....	....	67,700,000	86,200,000	153,900,000
1906—																						
January	446,200	25,000	46,000	37,700	0	32,500	123.0	203.0	5,000,000	5,900,000	10,900,000	25,000	52,800	42,600	0	196,000	0	109.0	180.0	5,100,000	6,000,000	11,100,000
February	329,400	355,000	55,500	55,500	0	218,400	183.0	228.0	7,800,000	9,700,000	17,500,000	179,800	68,800	65,700	0	194,700	0	147.5	192.5	7,800,000	9,700,000	17,500,000
March	870,000	355,000	61,500	61,500	0	747,000	183.0	228.0	8,600,000	10,800,000	19,400,000	180,000	76,200	72,600	0	721,200	0	148.0	193.0	8,600,000	10,800,000	19,400,000
April	719,500	355,000	59,500	59,500	2,000	598,500	183.0	228.0	8,400,000	10,400,000	18,800,000	180,000	65,300	64,000	1,100	414,100	0	167.0	212.0	8,400,000	10,400,000	18,800,000
May	927,200	355,000	61,500	61,500	2,800	801,400	183.0	228.0	8,600,000	10,800,000	19,400,000	355,000	61,500	61,500	2,800	0	891,400	183.0	228.0	8,600,000	10,800,000	19,400,000
June	954,500	355,000	59,500	59,500	3,400	832,100	183.0	228.0	8,400,000	10,400,000	18,800,000	355,000	59,500	59,500	3,400	0	832,100	183.0	228.0	8,400,000	10,400,000	18,800,000
July	389,500	355,000	61,500	61,500	4,000	262,500	183.0	228.0	8,600,000	10,800,000	19,400,000	355,000	61,500	61,500	4,000	0	262,500	183.0	228.0	8,600,000	10,800,000	19,400,000
August	62,800	355,000	61,500	61,500	3,800	0	178.0	223.0	8,400,000	10,600,000	19,000,000	355,000	61,500	61,500	3,800	0	0	178.0	223.0	8,400,000	10,600,000	19,000,000
September	24,900	291,000	59,500	59,500	2,400	0	162.5	207.5	7,400,000	9,500,000	16,900,000	291,000	59,500	59,500	2,400	0	0	162.5	207.5	7,400,000	9,500,000	16,900,000
October	18,400	194,500	61,500	61,500	1,300	0	133.0	178.0	6,300,000	8,400,000	14,700,000	194,500	61,500	61,500	1,300	0	0	133.0	178.0	6,300,000	8,400,000	14,700,000
November	33,500	88,600	42,000	54,600	500	0	94.5	140.5	3,100,000	5,900,000	9,000,000	88,600	42,000	54,600	500	0	0	94.5	140.5	3,100,000	5,900,000	9,000,000
December	244,100	25,000	52,900	42,300	0	0	99.0	155.0	4,200,000	5,200,000	9,400,000	25,000	52,900	42,300	0	0	0	99.0	155.0	4,200,000	5,200,000	9,400,000
Totals	5,020,000	....	682,400	676,100	20,200	3,492,400	....	....	84,800,000	108,400,000	193,200,000	....	723,000	706,800	19,300	1,526,000	1,896,000	....	....	84,900,000	108,500,000	193,400,000
1907—																						
January	255,300	173,900	61,500	61,500	0	0	157.0	202.0	7,400,000	9,600,000	17,000,000	173,900	75,800	72,200	0	101,200	0	148.0	193.0	8,600,000	10,700,000	19,300,000
February	824,400	306,200	55,500	55,500	0	664,600	182.5	227.5	7,800,000	9,700,000	17,500,000	180,000	68,900	65,500	0	690,000	0	148.0	193.0	7,800,000	9,700,000	17,500,000
March	1,519,300	355,000	61,500	61,500	0	1,396,300	183.0	228.0	8,600,000	10,800,000	19,400,000	180,000	76,200	72,600	0	1,370,500	0	148.0	193.0	8,690,000	10,800,000	19,400,000
April	930,600	355,000	59,500	59,500	2,000	809,600	183.0	228.0	8,400,000	10,400,000	18,800,000	180,000	65,400	64,000	1,100	625,100	0	167.0	212.0	8,400,000	10,400,000	18,800,000
May	749,700	355,000	61,500	61,500	2,800	623,900	183.0	228.0	8,600,000	10,800,000	19,400,000	355,000	61,500	61,500	2,800	0	623,900	183.0	228.0	8,600,000	10,800,000	19,400,000
June	660,900	355,000	59,500	59,500	3,400	538,500	183.0	228.0	8,400,000	10,400,000	18,800,000	355,000	59,500	59,500	3,400	0	538,500	183.0	228.0	8,400,000	10,400,000	18,800,000
July	338,400	355,000	61,500	61,500	4,000	211,400	183.0	228.0	8,600,000	10,800,000	19,400,000	355,000	61,500	61,500	4,000	0	211,400	183.0	228.0	8,600,000	10,800,000	19,400,000
August	92,000	355,000	61,500	61,500	3,800	2,900	181.0	226.0	8,500,000	10,700,000	19,200,000	355,000	61,500	61,500	3,800	0	2,900	181.0	226.0	8,500,000	10,700,000	19,200,000
September	48,400	317,300	59,500	59,500	2,600	0	170.0	215.0	7,800,000	9,800,000	17,600,000	317,300	59,500	59,500	2,600	0	0	170.0	215.0	7,800,000	9,800,000	17,600,000
October	42,600	244,100	61,500	61,500	1,500	0	153.0	198.0	7,200,000	9,400,000	16,600,000	244,100	61,500	61,500	1,500	0	0	153.0	198.0	7,200,000	9,400,000	16,600,000
November	49,000	162,200	59,500	59,500	700	0	129.5	174.5	5,900,000	8,000,000	13,900,000	162,200	59,500	59,500	700	0	0	129.5	174.5	5,900,000	8,000,000	13,900,000
December	109,800	91,500	61,500	61,500	0	0	106.0	151.0	5,000,000	7,100,000	12,100,000	91,500	61,500	61,500	0	0	0	106.0	151.0	5,000,000	7,100,000	12,100,000
Totals	5,620,400	....	724,000	724,000	20,800	4,247,200	....	....	92,200,000	117,500,000	209,700,000	....	772,300	760,300	19,900	2,786,800	1,376,700	....	....	93,400,000	118,600,000	212,000,000
1908—																						
January	159,900	78,300	61,500	61,500	0	0	117.5	162.5	5,500,000	7,700,000	13,200,000	78,300	61,500	61,500	0	0	0	117.5	162.5	5,500,000	7,700,000	13,200,000
February	112,700	115,200	57,500	57,500	0	0	125.5	170.5	5,600,000	7,500,000	13,100,000	115,200	57,500	57,500	0	0	0	125.5	170.5	5,600,000	7,500,000	13,100,000
March	202,500	112,900	61,500	61,500	0	0	138.0	183.0	6,500,000	8,700,000	15,200,000	112,900	64,300	63,600	0	7,500	0	136.5	181.5	6,800,000	8,900,000	15,700,000
April	267,000	192,400	59,500	59,500	1,200	0	166.0	211.0	7,600,000	9,600,000	17,200,000	180,000	68,800	66,700	1,100	0	0	159.0	204.0	8,400,000	10,400,000	18,800,000
May	282,400	339,200	61,500	61,500	2,700	140,900	183.0	228.0	8,600,000	10,800,000	19,400,000	310,400	61,800	61,600	2,500	0	111,900	182.0	227.0	8,600,000	10,800,000	19,400,000
June	154,900	355,000	59,500	59,500	3,400	37,400	183.0	228.0	8,400,000	10,400,000	18,800,000	355,000	59,500	59,500	3,400	0	37,400	183.0	228.0	8,400,000	10,400,000	18,800,000
July	53,500	350,100	61,500	61,500	3,900	0	176.0	221.0	8,300,000	10,500,000	18,800,000	350,100	61,500	61,500	3,900	0	0	176.0	221.0	8,300,000	10,500,000	18,800,000
August	12,300	276,700	61,500	61,500	3,000	0	156.5	201.5	7,400,000	9,500,000	16,900,000	276,700	61,500	61,500	3,000	0	0	156.5	201.5	7,400,000	9,500,000	16,900,000
September	7,300	163,000	59,500	59,500	1,500	0	117.0	162.0	5,400,000	7,400,000	12,800,000	163,000	59,500	59,500	1,500	0	0	117.0	162.0	5,400,000	7,400,000	12,800,000
October	23,600	49,800	21,200	23,400	400	0	80.5	126.0	1,300,000	2,300,000	3,600,000	49,800	21,200	23,400	400	0	0	80.5	126.0	1,300,000	2,300,000	3,600,000
November	26,200	28,400	24,400	5,000	200	0	68.5	114.0	1,300,000	400,000	1,700,000	28,400	24,400	5,000	200	0	0	68.5	114.0	1,300,000	400,000	1,700,000
December	37,200	25,000	30,800	6,400	0	0	68.0	113.0	1,600,000	600,000	2,200,000	25,000	30,800	6,400	0	0	0	68.0	113.0	1,600,000	600,000	2,200,000
Totals	1,339,500	....	619,900	578,300	16,300	178,300	....	....	67,500,000	85,400,000	152,900,000	....	632,300	587,700	16,000	7,500	149,300	....	....	68,600,000	86,400,000	155,000,000

Water release for power generation in accord with schedule proposed by American River Hydro-electric Company

Installed capacity of power plant. 35,000 k.v.a. P.F. = 0.80 L.F. = 1.00

With Flood Control

econd-feet. Maximum reservoir space required 175,000 acre-feet. Reservoir space held in reserve for flood control from
to any date in a season is more than 50 per cent of the normal precipitation to same date. Flood control reserve increased
'5,000 acre-feet on January 1; 175,000 acre-feet held in reserve from January 1 to April 1 and then decreased at uniform

poration acre-feet	Release through flood control outlets in acre-feet	Waste over spillway in acre-feet	Average power head in feet		Power yield in kilowatt hours		
			Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Total
0	0	0	76.0	127.5	3,100,000	3,300,000	6,400,000
0	0	0	70.0	115.0	3,000,000	2,400,000	5,400,000
0	0	0	69.0	114.0	3,200,000	3,600,000	6,800,000
300	0	0	129.0	174.0	5,900,000	8,000,000	13,900,000
2,200	0	234,300	180.5	225.5	8,500,000	10,700,000	19,200,000
3,400	0	43,700	182.5	227.5	8,400,000	10,400,000	18,800,000
3,900	0	0	173.0	218.0	8,200,000	10,300,000	18,500,000
2,800	0	0	150.5	195.5	7,100,000	9,300,000	16,400,000
1,200	0	0	106.0	151.0	4,900,000	6,900,000	11,800,000
300	0	0	69.0	116.5	500,000	600,000	1,100,000
200	0	0	68.0	113.0	1,500,000	0	1,500,000
0	0	0	70.0	119.5	2,100,000	1,600,000	3,700,000
14,300	0	278,000	....	....	56,400,000	67,100,000	123,500,000
0	823,600	0	147.5	192.5	8,600,000	10,800,000	19,400,000
0	255,200	0	148.0	193.0	7,800,000	9,700,000	17,500,000
0	348,300	0	148.0	193.0	8,600,000	10,800,000	19,400,000
1,100	255,000	0	167.0	212.0	8,400,000	10,400,000	18,800,000
2,800	0	591,000	183.0	228.0	8,600,000	10,800,000	19,400,000
3,400	0	269,900	183.0	228.0	8,400,000	10,400,000	18,800,000
4,000	0	26,000	182.5	227.5	8,600,000	10,800,000	19,400,000
3,400	0	0	170.0	215.0	8,000,000	10,200,000	18,200,000
2,000	0	0	145.5	190.5	6,700,000	8,700,000	15,400,000
800	0	0	102.0	148.0	4,700,000	6,700,000	11,400,000
200	0	0	68.0	....	1,200,000	0	1,200,000
0	0	0	68.0	113.0	2,100,000	200,000	2,300,000
17,700	1,682,100	886,900	....	....	81,700,000	99,500,000	181,200,000
0	0	0	70.5	117.0	3,000,000	2,800,000	5,800,000
0	238,100	0	142.0	187.0	7,100,000	9,100,000	16,200,000
0	137,000	0	148.0	193.0	8,600,000	10,800,000	19,400,000
1,100	200,900	0	167.0	212.0	8,400,000	10,400,000	18,800,000
2,800	0	828,400	183.0	228.0	8,600,000	10,800,000	19,400,000
3,400	0	355,400	183.0	228.0	8,400,000	10,400,000	18,800,000
4,000	0	15,600	182.0	227.0	8,600,000	10,700,000	19,300,000
3,500	0	0	168.0	213.0	7,900,000	10,100,000	18,000,000
1,800	0	0	141.5	186.5	6,500,000	8,500,000	15,000,000
800	0	0	94.0	146.5	3,900,000	5,300,000	9,200,000
200	0	0	68.0	....	1,200,000	0	1,200,000
0	0	0	72.5	121.5	2,900,000	2,800,000	5,700,000
17,600	576,000	1,199,400	....	....	75,100,000	91,700,000	166,800,000
0	192,300	0	131.0	188.0	6,900,000	8,700,000	15,600,000
0	445,100	0	148.0	193.0	8,100,000	10,100,000	18,200,000
0	658,400	0	148.0	193.0	8,600,000	10,800,000	19,400,000
1,100	394,800	0	167.0	212.0	8,400,000	10,400,000	18,800,000
2,800	0	481,200	183.0	228.0	8,600,000	10,800,000	19,400,000
3,400	0	276,600	183.0	228.0	8,400,000	10,400,000	18,800,000
4,000	0	17,800	182.5	227.5	8,600,000	10,800,000	19,400,000
3,500	0	0	169.0	214.0	8,000,000	10,100,000	18,100,000
1,900	0	0	143.0	188.0	6,500,000	8,600,000	15,100,000
800	0	0	102.0	147.0	4,800,000	7,000,000	11,800,000
200	0	0	69.0	116.0	2,000,000	800,000	2,800,000
0	0	0	80.5	126.0	3,800,000	5,600,000	9,400,000
17,700	1,690,600	775,600	....	....	82,700,000	104,100,000	186,800,000

TABLE 51. (Continued). POWER OUTPUT OF FOLSOM PLANT WITH AND WITHOUT FLOOD CONTROL

Folsom reservoir operated primarily for power generation
Auburn and Coloma reservoirs not constructed

Monthly Summary of Computations Carried out on a Daily Basis
(For corresponding yearly summary, see Table 50)

Measured daily flows at Fairoaks gaging station of United States Geological Survey used in computations

Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet

Water release for power generation in accord with schedule proposed by American River Hydro-electric Company

Installed capacity of power plant, 35,000 k.v.a. P.F.=0.80 L.F.=1.00

Without Flood Control

Year and Month	Measured run-off at Fairoaks in acre-feet	Stage of reservoir at beginning of month in acre-feet	Power draft through turbines in acre-feet: Upper unit, tailrace elevation 207 feet	Power draft through turbines in acre-feet: Lower unit, tailrace elevation 162 feet	Evaporation in acre-feet	Waste over spillway in acre-feet	Average power head in feet: Upper unit, tailrace elevation 207 feet	Average power head in feet: Lower unit, tailrace elevation 162 feet	Power yield in kilowatt hours: Upper unit, tailrace elevation 207 feet	Power yield in kilowatt hours: Lower unit, tailrace elevation 162 feet	Power yield in kilowatt hours: Total
1909—											
January	1,493,200	25,000	57,600	53,600	0	1,052,000	148.0	202.0	6,800,000	8,500,000	15,300,000
February	862,600	355,000	55,500	55,500	0	751,600	183.0	228.0	7,800,000	9,700,000	17,500,000
March	397,200	355,000	61,500	61,500	0	274,200	183.0	228.0	8,600,000	10,800,000	19,400,000
April	475,600	355,000	59,500	59,500	2,000	354,600	183.0	228.0	8,400,000	10,400,000	18,800,000
May	584,500	355,000	61,500	61,500	2,800	458,700	183.0	228.0	8,600,000	10,800,000	19,400,000
June	455,200	355,000	59,500	59,500	3,400	332,800	183.0	228.0	8,400,000	10,400,000	18,800,000
July	142,300	355,000	61,500	61,500	4,000	42,400	182.0	227.0	8,600,000	10,700,000	19,300,000
August	37,300	327,900	61,500	61,500	3,500	0	170.5	215.5	8,100,000	10,200,000	18,300,000
September	17,100	238,700	59,500	59,500	2,000	0	148.0	193.0	6,800,000	8,800,000	15,600,000
October	31,400	134,800	61,500	61,500	900	0	109.5	154.5	5,200,000	7,300,000	12,500,000
November	273,100	42,300	55,900	37,000	300	0	94.5	150.5	4,100,000	4,400,000	8,500,000
December	471,200	222,200	61,500	61,500	0	219,200	181.5	226.5	8,600,000	10,700,000	19,300,000
Totals	5,240,700	....	716,500	693,600	18,900	3,485,500	....	....	90,000,000	112,700,000	202,700,000
1910—											
January	524,000	351,200	61,500	61,500	0	397,200	183.0	228.0	8,600,000	10,800,000	19,400,000
February	291,200	355,000	55,500	55,500	0	180,200	183.0	228.0	7,800,000	9,700,000	17,500,000
March	645,700	355,000	61,500	61,500	0	522,700	183.0	228.0	8,600,000	10,800,000	19,400,000
April	624,300	355,000	59,500	59,500	2,000	503,300	183.0	228.0	8,400,000	10,400,000	18,800,000
May	488,800	355,000	61,500	61,500	2,800	363,000	183.0	228.0	8,600,000	10,800,000	19,400,000
June	134,700	355,000	59,500	59,500	3,400	38,400	182.0	227.0	8,300,000	10,400,000	18,700,000
July	31,700	328,900	61,500	61,500	3,700	0	170.0	215.0	8,000,000	10,200,000	18,200,000
August	13,100	233,900	61,500	61,500	2,600	0	145.0	190.0	6,800,000	9,000,000	15,800,000
September	12,000	121,400	53,600	53,200	1,100	0	100.0	148.5	4,300,000	6,100,000	10,400,000
October	21,000	25,500	21,000	0	300	0	68.5	....	1,100,000	0	1,100,000
November	32,000	25,200	32,000	0	200	0	68.0	....	1,700,000	0	1,700,000
December	98,200	25,000	55,500	42,700	0	0	76.0	124.0	3,300,000	4,100,000	7,400,000
Totals	2,916,700	....	641,100	577,900	16,100	2,004,800	....	....	75,500,000	92,300,000	167,800,000
1911—											
January	852,500	25,000	52,000	43,600	0	426,000	130.5	201.0	5,700,000	6,700,000	12,400,000
February	588,400	355,000	55,500	55,500	0	477,400	183.0	228.0	7,800,000	9,700,000	17,500,000
March	797,900	355,000	61,500	61,500	0	674,900	183.0	228.0	8,600,000	10,800,000	19,400,000
April	897,000	355,000	59,500	59,500	2,000	776,900	183.0	228.0	8,400,000	10,400,000	18,800,000
May	891,400	355,000	61,500	61,500	2,800	765,600	183.0	228.0	8,600,000	10,800,000	19,400,000
June	1,055,400	355,000	59,500	59,500	3,400	933,000	183.0	228.0	8,400,000	10,400,000	18,800,000
July	196,600	355,000	61,500	61,500	4,000	85,500	182.5	227.5	8,600,000	10,800,000	19,400,000
August	28,200	339,100	61,500	61,500	3,600	0	172.0	217.0	8,100,000	10,300,000	18,400,000
September	18,100	240,700	59,500	59,500	2,000	0	149.0	194.0	6,800,000	8,900,000	15,700,000
October	21,500	137,800	61,500	61,500	1,000	0	107.5	152.5	5,100,000	7,200,000	12,300,000
November	25,600	35,300	25,600	10,100	200	0	72.0	119.0	1,400,000	900,000	2,300,000
December	24,600	25,000	24,600	0	0	0	68.0	....	1,300,000	0	1,300,000
Totals	5,398,100	....	643,700	595,200	19,000	4,140,200	....	....	78,800,000	96,900,000	175,700,000
1912—											
January	69,600	25,000	50,600	19,000	0	0	68.5	114.0	2,700,000	1,700,000	4,400,000
February	46,000	25,000	44,600	1,400	0	0	68.0	113.0	2,300,000	100,000	2,400,000
March	118,200	25,000	60,800	51,800	0	0	75.5	121.5	3,500,000	4,900,000	8,400,000
April	170,600	30,600	59,500	59,500	300	0	89.0	134.0	4,100,000	6,100,000	10,200,000
May	420,700	81,900	61,500	61,500	800	23,800	153.5	198.5	7,200,000	9,400,000	16,600,000
June	283,600	355,000	59,500	59,500	3,400	166,400	183.0	228.0	8,400,000	10,400,000	18,800,000
July	51,000	349,800	61,500	61,500	3,900	0	175.5	220.5	8,300,000	10,400,000	18,700,000
August	12,800	273,900	61,500	61,500	2,900	0	155.5	200.5	7,300,000	9,500,000	16,800,000
September	19,700	160,800	59,500	59,500	1,400	0	120.0	165.0	5,500,000	7,500,000	13,000,000
October	15,000	60,100	15,000	34,400	500	0	80.0	129.5	900,000	3,400,000	4,300,000
November	87,400	25,200	49,300	38,100	200	0	78.5	129.0	3,100,000	3,800,000	6,900,000
December	36,800	25,000	34,700	2,100	0	0	68.0	113.0	1,800,000	200,000	2,000,000
Totals	1,331,400	....	618,000	509,800	13,400	190,200	....	....	55,100,000	67,400,000	122,500,000

With Flood Control

Maximum controlled flow at Fairoaks 100,000 second-feet. Maximum reservoir space required 175,000 acre-feet. Reservoir space held in reserve for flood control from December 1 to May 1 when total precipitation up to any date in a season is more than 50 per cent of the normal precipitation to same date. Flood control reserve increased at a uniform rate from zero on December 1 to 175,000 acre-feet on January 1; 175,000 acre-feet held in reserve from January 1 to April 1 and then decreased at uniform rate to zero on May 1

Year and Month	Stage of reservoir at beginning of month in acre-feet	Power draft through turbines in acre-feet: Upper unit, tailrace elevation 207 feet	Power draft through turbines in acre-feet: Lower unit, tailrace elevation 162 feet	Evaporation in acre-feet	Release through flood control outlets in acre-feet	Waste over spillway in acre-feet	Average power head in feet: Upper unit, tailrace elevation 207 feet	Average power head in feet: Lower unit, tailrace elevation 162 feet	Power yield in kilowatt hours: Upper unit, tailrace elevation 207 feet	Power yield in kilowatt hours: Lower unit, tailrace elevation 162 feet	Power yield in kilowatt hours: Total
1909—											
January	25,000	66,600	60,400	0	1,211,200	0	128.0	179.5	6,[illegible]00,000	8,500,000	15,400,000
February	180,000	68,800	65,500	0	728,300	0	148.0	193.0	7,800,000	9,700,000	17,500,000
March	180,000	76,200	72,500	0	248,500	0	148.0	193.0	8,600,000	10,800,000	19,400,000
April	180,000	65,400	64,000	1,100	170,100	0	167.0	212.0	8,400,000	10,400,000	18,800,000
May	355,000	61,500	61,500	2,800	0	458,700	183.0	228.0	8,600,000	10,800,000	19,400,000
June	355,000	59,500	59,500	3,400	0	332,800	183.0	228.0	8,400,000	10,400,000	18,800,000
July	355,000	61,500	61,500	4,000	0	42,400	182.0	227.0	8,600,000	10,700,000	19,300,000
August	327,900	61,500	61,500	3,500	0	0	170.5	215.5	8,100,000	10,200,000	18,300,000
September	238,700	59,500	59,500	2,000	0	0	148.0	193.0	6,800,000	8,800,000	15,600,000
October	134,800	61,500	61,500	900	0	0	109.5	154.5	5,200,000	7,300,000	12,500,000
November	42,300	55,900	37,000	300	0	0	94.5	150.5	4,100,000	4,400,000	8,500,000
December	222,200	67,600	66,200	0	379,600	0	166.0	211.0	8,600,000	10,700,000	19,300,000
Totals	....	765,500	730,600	18,000	2,737,700	833,900	..	.	90,100,000	112,700,000	202,800,000
1910—											
January	180,000	76,200	72,600	0	375,200	0	148.0	193.0	8,600,000	10,800,000	19,400,000
February	180,000	68,800	65,500	0	156,900	0	148.0	193.0	7,800,000	9,700,000	17,500,000
March	180,000	76,300	72,500	0	496,900	0	148.0	193.0	8,600,000	10,800,000	19,400,000
April	180,000	65,300	64,000	1,100	318,900	0	167.0	212.0	8,400,000	10,400,000	18,800,000
May	355,000	61,500	61,500	2,800	0	363,000	183.0	228.0	8,600,000	10,800,000	19,400,000
June	355,000	59,500	59,500	3,400	0	38,400	182.0	227.0	8,300,000	10,400,000	18,700,000
July	328,900	61,500	61,500	3,700	0	0	170.0	215.0	8,000,000	10,200,000	18,200,000
August	233,900	61,500	61,500	2,600	0	0	145.0	190.0	6,800,000	9,000,000	15,800,000
September	121,400	53,600	53,200	1,100	0	0	100.0	148.5	4,300,000	6,100,000	10,400,000
October	25,500	21,000	0	300	0	0	68.5		1,100,000	0	1,100,000
November	25,200	32,000	0	200	0	0	68.0		1,700,000	0	1,700,000
December	25,000	55,500	42,700	0	0	0	76.0	124.0	3,300,000	4,100,000	7,400,000
Totals	....	692,700	614,500	15,200	1,347,900	401,400			75,500,000	92,300,000	167,800,000
1911—											
January	25,000	60,100	49,700	0	587,700	0	117.0	182.0	6,000,000	7,000,000	13,000,000
February	180,000	68,900	65,500	0	454,000	0	148.0	193.0	7,800,000	9,700,000	17,500,000
March	180,000	76,200	72,500	0	649,200	0	148.0	193.0	8,600,000	10,800,000	19,400,000
April	180,000	65,400	64,000	1,100	592,400	0	167.0	212.0	8,400,000	10,400,000	18,800,000
May	355,000	61,500	61,500	2,800	0	765,600	183.0	228.0	8,600,000	10,800,000	19,400,000
June	355,000	59,500	59,500	3,400	0	933,000	183.0	228.0	8,400,000	10,400,000	18,800,000
July	355,000	61,500	61,500	4,000	0	85,500	182.5	227.5	8,600,000	10,800,000	19,400,000
August	339,100	61,500	61,500	3,600	0	0	172.0	217.0	8,100,000	10,300,000	18,400,000
September	240,700	59,500	59,500	2,000	0	0	149.0	194.0	6,800,000	8,900,000	15,700,000
October	137,800	61,500	61,500	1,000	0	0	107.5	152.5	5,100,000	7,200,000	12,300,000
November	35,300	25,600	10,100	200	0	0	72.0	119.0	1,400,000	900,000	2,300,000
December	25,000	24,600	0	0	0	0	68.0	...	1,300,000	0	1,300,000
Totals	....	685,800	626,800	18,100	2,284,300	1,783,100	......	.	79,100,000	97,200,000	176,300,000
1912—											
January	25,000	50,600	19,000	0	0	0	68.5	114.0	2,700,000	1,700,000	4,400,000
February	25,000	44,600	1,400	0	0	0	68.0	113.0	2,300,000	100,000	2,400,000
March	25,000	60,800	51,800	0	0	0	75.5	121.5	3,500,000	4,900,000	8,400,000
April	30,600	59,500	59,500	300	0	0	89.0	134.0	4,100,000	6,100,000	10,200,000
May	81,900	61,500	61,500	800	0	23,800	153.5	198.5	7,200,000	9,400,000	16,600,000
June	355,000	59,500	59,500	3,400	0	166,400	183.0	228.0	8,400,000	10,400,000	18,800,000
July	349,800	61,500	61,500	3,900	0	0	175.5	220.5	8,300,000	10,100,000	18,700,000
August	273,900	61,500	61,500	2,900	0	0	155.5	200.5	7,300,000	9,500,000	16,800,000
September	160,800	59,500	59,500	1,400	0	0	120.0	165.0	5,500,000	7,500,000	13,000,000
October	60,100	15,000	31,400	500	0	0	80.0	129.5	900,000	3,400,000	4,300,000
November	25,200	49,300	38,100	200	0	0	78.5	129.0	3,100,000	3,800,000	6,900,000
December	25,000	34,700	2,100	0	0	0	68.0	113.0	1,800,000	200,000	2,000,000
Totals	....	618,000	509,800	13,400	0	190,200	....	....	55,100,000	67,400,000	122,500,000

Water release for power generation in accord with schedule proposed by American River Hydro-electric Company

Installed capacity of power plant, 35,000 k.v.a. P.F. = 0.80 L.F. = 1.00

With Flood Control

econd-feet. Maximum reservoir space required 175,000 acre-feet. Reservoir space held in reserve for flood control from to any date in a season is more than 50 per cent of the normal precipitation to same date. Flood control reserve increased 5,000 acre-feet on January 1; 175,000 acre-feet held in reserve from January 1 to April 1 and then decreased at uniform

poration acre-feet	Release through flood control outlets in acre-feet	Waste over spillway in acre-feet	Average power head in feet		Power yield in kilowatt hours		
			Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Total
0	0	0	72.0	117.5	3,400,000	3,600,000	7,000,000
0	149,400	0	88.0	133.0	4,000,000	5,000,000	9,000,000
0	126,000	0	148.0	193.0	8,600,000	10,800,000	19,400,000
1,100	243,500	0	167.0	212.0	8,400,000	10,400,000	18,800,000
2,800	0	507,400	183.0	228.0	8,600,000	10,800,000	19,400,000
3,400	0	408,100	183.0	228.0	8,400,000	10,400,000	18,800,000
4,000	0	12,800	181.5	226.5	8,600,000	10,700,000	19,300,000
3,400	0	0	167.0	212.0	7,900,000	10,000,000	17,900,000
1,800	0	0	139.5	184.5	6,400,000	8,400,000	14,800,000
800	0	0	93.5	145.0	3,200,000	5,500,000	8,700,000
200	0	0	68.0	....	600,000	0	600,000
0	0	0	68.0	113.0	1,600,000	200,000	1,800,000
17,500	518,900	928,300	....	....	69,700,000	85,800,000	155,500,000
0	0	0	68.0	....	900,000	0	900,000
0	0	0	89.5	139.5	3,400,000	4,800,000	8,200,000
0	60,400	0	124.0	169.0	6,300,000	8,400,000	14,700,000
1,100	134,600	0	167.0	212.0	8,400,000	10,400,000	18,800,000
2,800	0	181,600	183.0	228.0	8,600,000	10,800,000	19,400,000
3,400	0	24,400	182.0	227.0	8,300,000	10,400,000	18,700,000
3,700	0	0	167.5	212.5	8,000,000	10,000,000	18,000,000
2,400	0	0	137.5	182.5	6,500,000	8,600,000	15,100,000
1,000	0	0	89.0	140.0	3,500,000	4,900,000	8,400,000
300	0	0	68.0	113.0	2,400,000	1,100,000	3,500,000
200	0	0	68.0	113.0	2,400,000	200,000	2,600,000
0	0	0	68.0	113.0	2,400,000	200,000	2,600,000
14,900	195,000	206,000	....	....	61,100,000	69,800,000	130,900,000
0	0	0	68.0	113.0	1,900,000	500,000	2,400,000
0	95,200	0	119.5	175.5	5,900,000	6,800,000	12,700,000
0	165,600	0	148.0	193.0	8,600,000	10,800,000	19,400,000
1,200	256,200	0	167.0	212.0	8,400,000	10,400,000	18,800,000
2,800	0	467,900	183.0	228.0	8,600,000	10,800,000	19,400,000
3,400	0	15,700	181.0	226.0	8,300,000	10,300,000	18,600,000
3,500	0	0	165.0	210.0	7,800,000	9,900,000	17,700,000
2,200	0	0	133.5	178.5	6,300,000	8,400,000	14,700,000
900	0	0	87.5	139.0	1,700,000	4,600,000	6,300,000
300	0	0	68.5	....	500,000	0	500,000
200	0	0	68.0	....	500,000	0	500,000
0	0	0	68.0	113.0	2,000,000	400,000	2,400,000
14,500	517,000	483,600	....	....	60,500,000	72,900,000	135,400,000
0	0	0	68.0	113.0	2,000,000	100,000	2,100,000
0	0	0	68.0	113.0	1,900,000	100,000	2,000,000
0	0	0	105.0	150.0	5,000,000	7,100,000	12,100,000
900	24,800	0	159.5	204.5	7,400,000	9,500,000	16,900,000
2,800	0	313,100	183.0	228.0	8,600,000	10,800,000	19,400,000
3,400	0	52,500	182.5	227.5	8,400,000	10,400,000	18,800,000
3,800	0	0	172.5	217.5	8,200,000	10,300,000	18,500,000
2,700	0	0	148.5	193.5	7,000,000	9,200,000	16,200,000
1,200	0	0	106.5	151.5	4,800,000	6,900,000	11,700,000
300	0	0	68.0	113.0	1,800,000	0	1,800,00
200	0	0	83.5	137.5	3,200,000	4,000,000	7,200,000
0	58,000	0	136.5	181.5	6,700,000	8,800,000	15,500,000
15,300	82,800	365,600	....	....	65,000,000	77,200,000	142,200,000

TABLE 51. (Continued). POWER OUTPUT OF FOLSOM PLANT WITH AND WITHOUT FLOOD CONTROL

Folsom reservoir operated primarily for power generation
Auburn and Coloma reservoirs not constructed

Monthly Summary of Computations Carried out on a Daily Basis
(For corresponding yearly summary, see Table 50)

Measured daily flows at Fairoaks gaging station of United States Geological Survey used in computations

Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet

Water release for power generation in accord with schedule proposed by American River Hydro-electric Company
Installed capacity of power plant, 35,000 k.v.a. P.F. = 0.80 L.F. = 1.00

Without Flood Control

Year and Month	Measured run-off at Fairoaks in acre-feet	Stage of reservoir at beginning of month in acre-feet	Power draft through turbines in acre-feet: Upper unit, tailrace elevation 207 feet	Power draft through turbines in acre-feet: Lower unit, tailrace elevation 162 feet	Evaporation in acre-feet	Waste over spillway in acre-feet	Average power head in feet: Upper unit, tailrace elevation 207 feet	Average power head in feet: Lower unit, tailrace elevation 162 feet	Power yield in kilowatt hours: Upper unit, tailrace elevation 207 feet	Power yield in kilowatt hours: Lower unit, tailrace elevation 162 feet	Power yield in kilowatt hours: Total
1913—											
January	96,800	25,000	52,300	33,700	0	0	76.0	127.5	3,100,000	3,300,000	6,400,000
February	71,500	35,800	55,500	26,800	0	0	70.0	115.0	3,000,000	2,400,000	5,400,000
March	107,400	25,000	60,600	40,600	0	0	69.0	114.0	3,200,000	3,600,000	6,800,000
April	359,100	31,200	59,500	59,500	300	0	129.0	174.0	5,900,000	8,000,000	13,900,000
May	443,500	271,000	61,500	61,500	2,200	234,300	180.5	225.5	8,500,000	10,700,000	19,200,000
June	151,400	355,000	59,500	59,500	3,400	43,700	182.5	227.5	8,400,000	10,400,000	18,800,000
July	37,700	340,300	61,500	61,500	3,900	0	173.0	218.0	8,200,000	10,300,000	18,500,000
August	17,400	251,100	61,500	61,500	2,800	0	150.5	195.5	7,100,000	9,300,000	16,400,000
September	9,200	142,700	59,500	59,500	1,200	0	106.0	151.0	4,900,000	6,900,000	11,800,000
October	9,500	31,700	9,500	6,200	300	0	69.0	116.5	500,000	600,000	1,100,000
November	28,900	25,200	28,600	300	200	0	68.0	113.0	1,500,000	0	1,500,000
December	132,100	25,000	38,900	17,500	0	0	70.0	119.5	2,100,000	1,600,000	3,700,000
Totals	1,464,500	...	608,400	488,100	14,300	278,000	...	...	56,400,000	67,100,000	123,500,000
1914—											
January	1,052,000	100,700	61,500	61,500	0	674,700	179.5	224.5	8,500,000	10,600,000	19,100,000
February	389,500	355,000	55,500	55,500	0	278,500	183.0	228.0	7,800,000	9,700,000	17,500,000
March	497,000	355,000	61,500	61,500	0	374,000	183.0	228.0	8,600,000	10,800,000	19,400,000
April	560,400	355,000	59,500	59,500	2,000	439,400	183.0	228.0	8,400,000	10,400,000	18,800,000
May	716,800	355,000	61,500	61,500	2,800	591,000	183.0	228.0	8,600,000	10,800,000	19,400,000
June	392,300	355,000	59,500	59,500	3,400	269,900	183.0	228.0	8,400,000	10,400,000	18,800,000
July	129,900	355,000	61,500	61,500	4,000	26,000	182.5	227.5	8,600,000	10,800,000	19,400,000
August	27,700	331,900	61,500	61,500	3,400	0	170.0	215.0	8,000,000	10,200,000	18,200,000
September	11,300	233,200	59,500	59,500	2,000	0	145.5	190.5	6,700,000	8,700,000	15,400,000
October	20,400	123,500	59,200	58,700	800	0	102.0	148.0	4,700,000	6,700,000	11,400,000
November	22,300	25,200	22,300	0	200	0	68.0	...	1,200,000	0	1,200,000
December	41,900	25,000	39,400	2,500	0	0	68.0	113.0	2,100,000	200,000	2,300,000
Totals	3,861,500	...	662,400	602,700	18,600	2,653,500	...	...	81,600,000	99,300,000	180,900,000
1915—											
January	95,000	25,000	55,100	30,600	0	0	70.5	117.0	3,000,000	2,800,000	5,800,000
February	511,600	34,300	55,500	55,500	0	79,900	160.5	205.5	6,800,000	8,800,000	15,600,000
March	285,800	355,000	61,500	61,500	0	162,800	183.0	228.0	8,600,000	10,800,000	19,400,000
April	506,400	355,000	59,500	59,500	2,000	385,400	183.0	228.0	8,400,000	10,400,000	18,800,000
May	954,200	355,000	61,500	61,500	2,800	828,400	183.0	228.0	8,600,000	10,800,000	19,400,000
June	477,800	355,000	59,500	59,500	3,400	355,400	183.0	228.0	8,400,000	10,400,000	18,800,000
July	108,600	355,000	61,500	61,500	4,000	15,600	182.0	227.0	8,600,000	10,700,000	19,300,000
August	24,100	321,000	61,500	61,500	3,500	0	168.0	213.0	7,900,000	10,100,000	18,000,000
September	13,400	218,600	59,500	59,500	1,800	0	141.5	186.5	6,500,000	8,500,000	15,000,000
October	13,300	111,200	50,900	47,600	800	0	94.0	146.5	3,900,000	5,300,000	9,200,000
November	22,500	25,200	22,500	0	200	0	68.0	...	1,200,000	0	1,200,000
December	80,600	25,000	50,500	30,100	0	0	72.5	121.5	2,900,000	2,800,000	5,700,000
Totals	3,093,300	...	659,000	588,300	18,500	1,827,500	...	...	74,800,000	91,400,000	166,200,000
1916—											
January	476,000	25,000	59,500	57,500	0	29,000	140.0	190.0	6,500,000	8,400,000	14,900,000
February	584,300	355,000	57,500	57,500	0	469,300	183.0	228.0	8,100,000	10,100,000	18,200,000
March	807,100	355,000	61,500	61,500	0	684,100	183.0	228.0	8,600,000	10,800,000	19,400,000
April	700,200	355,000	59,500	59,500	2,000	579,200	183.0	228.0	8,400,000	10,400,000	18,800,000
May	607,000	355,000	61,500	61,500	2,800	481,200	183.0	228.0	8,600,000	10,800,000	19,100,000
June	399,000	355,000	59,500	59,500	3,400	276,600	183.0	228.0	8,400,000	10,400,000	18,800,000
July	121,200	355,000	61,500	61,500	4,000	17,800	182.5	227.5	8,600,000	10,800,000	19,400,000
August	20,900	331,400	61,500	61,500	3,500	0	189.0	214.0	8,000,000	10,100,000	18,100,000
September	13,100	225,800	59,500	59,500	1,900	0	143.0	188.0	6,500,000	8,600,000	15,100,000
October	38,500	118,000	61,500	61,500	800	0	102.0	147.0	4,800,000	7,000,000	11,800,000
November	38,700	32,700	37,000	9,200	200	0	69.0	116.0	2,000,000	800,000	2,800,000
December	123,500	25,000	61,200	58,200	0	0	80.5	126.0	3,800,000	5,600,000	9,400,000
Totals	3,929,500	...	701,200	668,400	18,600	2,537,200	...	...	82,300,000	103,800,000	186,100,000

With Flood Control

Maximum controlled flow at Fairoaks 100,000 second-feet. Maximum reservoir space required 175,000 acre-feet. Reservoir space held in reserve for flood control from December 1 to May 1 when total precipitation up to any date in a season is more than 50 per cent of the normal precipitation to same date. Flood control reserve increased at a uniform rate from zero on December 1 to 175,000 acre-feet on January 1; 175,000 acre-feet held in reserve from January 1 to April 1 and then decreased at uniform rate to zero on May 1

Year and Month	Stage of reservoir at beginning of month in acre-feet	Power draft through turbines in acre-feet: Upper unit, tailrace elevation 207 feet	Power draft through turbines in acre-feet: Lower unit, tailrace elevation 162 feet	Evaporation in acre-feet	Release through flood control outlets in acre-feet	Waste over spillway in acre-feet	Average power head in feet: Upper unit, tailrace elevation 207 feet	Average power head in feet: Lower unit, tailrace elevation 162 feet	Power yield in kilowatt hours: Upper unit, tailrace elevation 207 feet	Power yield in kilowatt hours: Lower unit, tailrace elevation 162 feet	Power yield in kilowatt hours: Total
1913—											
January	25,000	52,300	33,700	0	0	0	76.0	127.5	3,100,000	3,300,000	6,400,000
February	35,800	55,500	26,800	0	0	0	70.0	116.0	3,000,000	2,400,000	5,400,000
March	25,000	60,600	40,600	0	0	0	69.0	114.0	3,200,000	3,600,000	6,800,000
April	31,200	59,500	59,500	300	0	0	129.0	174.0	5,900,000	8,000,000	13,900,000
May	271,000	61,500	61,500	2,200	0	234,300	180.5	225.5	8,500,000	10,700,000	19,200,000
June	355,000	59,500	59,500	3,400	0	43,700	182.5	227.5	8,400,000	10,400,000	18,800,000
July	340,300	61,500	61,500	3,900	0	0	173.0	218.0	8,200,000	10,300,000	18,500,000
August	251,100	61,500	61,500	2,800	0	0	150.5	195.5	7,100,000	9,300,000	16,400,000
September	142,700	59,500	59,500	1,200	0	0	106.0	151.0	4,900,000	6,900,000	11,800,000
October	31,700	9,500	6,200	300	0	0	69.0	116.5	500,000	600,000	1,100,000
November	25,200	28,600	300	200	0	0	68.0	113.0	1,500,000	0	1,500,000
December	25,000	38,900	17,500	0	0	0	70.0	119.5	2,100,000	1,600,000	3,700,000
Totals	...	608,400	488,100	14,300	0	278,000	...	...	56,400,000	67,100,000	123,500,000
1914—											
January	100,700	76,500	72,600	0	823,600	0	147.5	192.5	8,600,000	10,800,000	19,400,000
February	180,000	68,800	65,500	0	255,200	0	148.0	193.0	7,800,000	9,700,000	17,500,000
March	180,000	76,200	72,500	0	348,300	0	148.0	193.0	8,600,000	10,800,000	19,400,000
April	180,000	65,300	64,000	1,100	255,000	0	167.0	212.0	8,400,000	10,400,000	18,800,000
May	355,000	61,500	61,500	2,800	0	591,000	183.0	228.0	8,600,000	10,800,000	19,400,000
June	355,000	59,500	59,500	3,400	0	269,900	183.0	228.0	8,400,000	10,400,000	18,800,000
July	355,000	61,500	61,500	4,000	0	26,000	182.5	227.5	8,600,000	10,800,000	19,400,000
August	331,900	61,500	61,500	3,400	0	0	170.0	215.0	8,000,000	10,200,000	18,200,000
September	233,200	59,500	59,500	2,000	0	0	145.5	190.5	6,700,000	8,700,000	15,400,000
October	123,500	59,200	58,700	800	0	0	102.0	148.0	4,700,000	6,700,000	11,400,000
November	25,200	22,300	0	200	0	0	68.0		1,200,000	0	1,200,000
December	25,000	39,400	2,500	0	0	0	68.0	113.0	2,100,000	200,000	2,300,000
Totals	...	711,200	639,300	17,700	1,682,100	886,900	...	...	81,700,000	99,500,000	181,200,000
1915—											
January	25,000	55,100	30,600	0	0	0	70.5	117.0	3,000,000	2,800,000	5,800,000
February	34,300	65,100	62,700	0	238,100	0	142.0	187.0	7,100,000	9,100,000	16,200,000
March	180,000	76,300	72,500	0	137,000	0	148.0	193.0	8,600,000	10,800,000	19,400,000
April	180,000	65,400	64,000	1,100	200,900	0	167.0	212.0	8,400,000	10,400,000	18,800,000
May	355,000	61,500	61,500	2,800	0	828,400	183.0	228.0	8,600,000	10,800,000	19,400,000
June	355,000	59,500	59,500	3,400	0	355,400	183.0	228.0	8,400,000	10,400,000	18,800,000
July	355,000	61,500	61,500	4,000	0	15,600	182.0	227.0	8,600,000	10,700,000	19,300,000
August	321,000	61,500	61,500	3,500	0	0	168.0	213.0	7,900,000	10,100,000	18,000,000
September	218,600	59,500	59,500	1,800	0	0	141.5	186.5	6,500,000	8,500,000	15,000,000
October	111,200	50,900	47,600	800	0	0	94.0	146.5	3,900,000	5,300,000	9,200,000
November	25,200	22,500	0	200	0	0	68.0	...	1,200,000	0	1,200,000
December	25,200	50,500	30,100	0	0	0	72.5	121.5	2,900,000	2,800,000	5,700,000
Totals	...	689,300	611,000	17,600	576,000	1,199,400	...	...	75,100,000	91,700,000	166,800,000
1916—											
January	25,000	66,200	62,500	0	192,300	0	131.0	188.0	6,900,000	8,700,000	15,600,000
February	180,000	71,300	67,900	0	445,100	0	148.0	193.0	8,100,000	10,100,000	18,200,000
March	180,000	76,200	72,500	0	658,400	0	148.0	193.0	8,600,000	10,800,000	19,400,000
April	180,000	65,300	64,000	1,100	394,800	0	167.0	212.0	8,400,000	10,400,000	18,800,000
May	355,000	61,500	61,500	2,800	0	481,200	183.0	228.0	8,600,000	10,800,000	19,400,000
June	355,000	59,500	59,500	3,400	0	276,600	183.0	228.0	8,400,000	10,400,000	18,800,000
July	355,000	61,500	61,500	4,000	0	17,800	182.5	227.5	8,600,000	10,800,000	19,400,000
August	331,400	61,500	61,500	3,500	0	0	169.0	214.0	8,000,000	10,100,000	18,100,000
September	225,800	59,500	59,500	1,900	0	0	143.0	188.0	6,500,000	8,600,000	15,100,000
October	118,000	61,500	61,500	800	0	0	102.0	147.0	4,800,000	7,000,000	11,800,000
November	32,700	37,000	9,200	200	0	0	69.0	116.0	2,000,000	800,000	2,800,000
December	25,000	61,200	58,200	0	0	0	80.5	126.0	3,800,000	5,600,000	9,400,000
Totals	...	742,200	699,300	17,700	1,690,600	775,600	...	...	82,700,000	104,100,000	186,800,000

Water release for power generation in accord with schedule proposed by American River Hydro-electric Company

Installed capacity of power plant, 35,000 k.v.a. P.F. = 0.80 L.F. = 1.00

With Flood Control

ond-feet. Maximum reservoir space required 175,000 acre-feet. Reservoir space held in reserve for flood control from any date in a season is more than 50 per cent of the normal precipitation to same date. Flood control reserve increased 000 acre-feet on January 1; 175,000 acre-feet held in reserve from January 1 to April 1 and then decreased at uniform

...oration ...e-feet	Release through flood control outlets in acre-feet	Waste over spillway in acre-feet	Average power head in feet		Power yield in kilowatt hours		
			Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Total
0	324,600	0	148.0	193.0	8,600,000	10,800,000	19,400,000
0	181,300	0	148.0	193.0	7,800,000	9,700,000	17,500,000
0	385,500	0	148.0	193.0	8,600,000	10,800,000	19,400,000
1,100	126,000	0	167.0	212.0	8,400,000	10,400,000	18,800,000
2,800	0	400,900	183.0	228.0	8,600,000	10,800,000	19,400,000
3,400	0	249,100	183.0	228.0	8,400,000	10,400,000	18,800,000
4,000	0	3,100	180.0	225.0	8,500,000	10,700,000	19,200,000
3,200	0	0	163.0	208.0	7,700,000	9,800,000	17,500,000
1,700	0	0	133.5	178.5	6,100,000	8,200,000	14,300,000
700	0	0	89.0	139.0	2,700,000	5,200,000	7,900,000
200	0	0	68.0	113.0	2,100,000	600,000	2,700,000
0	0	0	74.5	120.0	3,500,000	3,700,000	7,200,000
17,100	1,017,400	653,100	....	....	81,000,000	101,100,000	182,100,000
0	0	0	107.5	152.5	5,100,000	7,200,000	12,300,000
0	127,500	0	123.5	168.5	5,800,000	7,800,000	13,600,000
0	189,200	0	148.0	193.0	8,600,000	10,800,000	19,400,000
1,100	181,800	0	167.0	212.0	8,400,000	10,400,000	18,800,000
2,800	0	891,700	183.0	228.0	8,600,000	10,800,000	19,400,000
3,400	0	548,000	183.0	228.0	8,400,000	10,400,000	18,800,000
4,000	0	15,700	181.0	226.0	8,600,000	10,700,000	19,300,000
3,300	0	0	165.5	210.5	7,800,000	10,000,000	17,800,000
1,800	0	0	137.5	182.5	6,300,000	8,400,000	14,700,000
700	0	0	92.5	142.0	4,100,000	5,500,000	9,600,000
200	0	0	70.0	118.5	2,400,000	1,700,000	4,100,000
0	127,100	0	125.5	179.0	6,200,000	7,700,000	13,900,000
17,300	625,600	1,455,400	....	....	80,300,000	101,400,000	181,700,000
0	119,400	0	148.0	193.0	8,600,000	10,800,000	19,400,000
0	41,000	0	148.0	193.0	7,800,000	9,700,000	17,500,000
0	69,200	0	148.0	193.0	8,600,000	10,800,000	19,400,000
1,100	260,400	0	167.0	212.0	8,400,000	10,400,000	18,800,000
2,800	0	486,600	183.0	228.0	8,600,000	10,800,000	19,400,000
3,400	0	155,900	183.0	228.0	8,400,000	10,400,000	18,800,000
4,000	0	11,000	181.5	226.5	8,600,000	10,700,000	19,300,000
3,400	0	0	166.0	211.0	7,800,000	10,000,000	17,800,000
1,800	0	0	140.0	185.0	6,400,000	8,500,000	14,900,000
800	0	0	103.0	148.0	4,900,000	7,000,000	11,900,000
200	0	0	68.0	114.0	1,500,000	100,000	1,600,000
0	0	0	68.0	....	1,400,000	0	1,400,000
17,500	490,000	653,500	....	....	81,000,000	99,200,000	180,200,000
0	0	0	68.0	113.0	1,900,000	200,000	2,100,000
0	0	0	87.0	135.0	3,800,000	4,800,000	8,600,000
0	0	0	69.5	119.0	2,800,000	1,400,000	4,200,000
300	0	0	76.0	122.5	3,500,000	4,500,000	8,000,000
500	0	0	77.5	125.5	3,400,000	4,300,000	7,700,000
400	0	0	70.0	....	700,000	0	700,000
500	0	0	69.5	....	100,000	0	100,000
500	0	0	68.5	....	100,000	0	100,000
400	0	0	68.0	....	100,000	0	100,000
300	0	0	68.0	113.0	600,000	200,000	800,000
200	0	0	70.0	119.0	2,300,000	1,400,000	3,700,000
0	0	0	70.0	116.0	3,100,000	2,100,000	5,200,000
3,100	0	0	....	....	22,400,000	18,900,000	41,300,000

TABLE 51. (Continued). POWER OUTPUT OF FOLSOM PLANT WITH AND WITHOUT FLOOD CONTROL

Folsom reservoir operated primarily for power generation
Auburn and Coloma reservoirs not constructed

Monthly Summary of Computations Carried out on a Daily Basis
(For corresponding yearly summary, see Table 50)

Measured daily flows at Fairoaks gaging station of United States
Geological Survey used in computations

Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet

Water release for power generation in accord with schedule proposed
by American River Hydro-electric Company

Installed capacity of power plant, 35,000 k.v.a. P.F. = 0.80 L.F. = 1.00

Without Flood Control

Year and Month	Measured run-off at Fairoaks in acre-feet	Stage of reservoir at beginning of month in acre-feet	Power draft through turbines in acre-feet		Evaporation in acre-feet	Waste over spillway in acre-feet	Average power head in feet		Power yield in kilowatt hours		
			Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet			Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Total
1917—											
January	97,500	29,100	61,300	38,800	0	0	72 0	117 5	3,400,000	3,600,000	7,000,000
February	407,200	26,500	55,500	44,500	0	0	91 0	136 0	3,900,000	4,800,000	8,700,000
March	274,800	333,700	61,500	61,500	0	130,500	183 0	228 0	8,600,000	10,800,000	19,400,000
April	549,200	355,000	59,500	59,500	2,000	428,200	183 0	228 0	8,400,000	10,400,000	18,800,000
May	633,200	355,000	61,500	61,500	2,800	507,400	183 0	228 0	8,600,000	10,800,000	19,400,000
June	530,500	355,000	59,500	59,500	3,400	408,100	183 0	228 0	8,400,000	10,100,000	18,800,000
July	103,300	355,000	61,500	61,500	4,000	12,800	181 5	226 5	8,600,000	10,700,000	19,300,000
August	22,800	318,500	61,500	61,500	3,400	0	167.0	212.0	7,900,000	10,000,000	17,900,000
September	11,800	214,900	59,500	59,500	1,800	0	139 5	184.5	6,400,000	8,400,000	14,800,000
October	11,400	105,900	41,700	49,600	800	0	93.5	145.0	3,200,000	5,500,000	8,700,000
November	10,800	25,200	10,800	0	200	0	68.0	. . .	600,000	0	600,000
December	32,000	25,000	29,400	2,600	0	0	68.0	113.0	1,600,000	200,000	1,800,000
Totals	2,684,500	. . .	623,200	560,000	18,400	1,487,000	. . .	. . .	69,600,000	85,600,000	155,200,000
1918—											
January	17,400	25,000	17,400	0	0	0	68.0	. . .	900,000	0	900,000
February	124,000	25,000	48,100	43,800	0	0	89.5	139 5	3,400,000	4,800,000	8,200,000
March	312,900	57,100	61,500	61,500	0	0	130.5	175.5	6,200,000	8,300,000	14,500,000
April	410,400	247,000	59,500	59,500	1,500	211,900	179.0	224 0	8,200,000	10,300,000	18,500,000
May	307,400	355,000	61,500	61,500	2,800	181,600	183.0	228 0	8,600,000	10,800,000	19,400,000
June	115,300	355,000	59,500	59,500	3,400	21,400	182 0	227 0	8,300,000	10,400,000	18,700,000
July	19,900	323,500	61,500	61,500	3,700	0	167.5	212.5	8,000,000	10,000,000	18,000 000
August	4,300	216,700	61,500	61,500	2,400	0	137.5	182.5	6,500,000	8,600,000	15,100,000
September	24,700	95,600	48,300	45,600	1,000	0	89.0	140.0	3,500,000	4,900,000	8,400,000
October	57,800	25,400	44,700	13,000	300	0	68 0	113.0	2,400,000	1,100,000	3,500,000
November	47,900	25,200	45,600	2,300	200	0	68 0	113.0	2,400,000	200,000	2,600,000
December	47,800	25,000	46,000	1,800	0	0	68.0	113.0	2,400,000	200,000	2,600,000
Totals	1,519,800	. . .	615,100	471,500	15,300	417,900	. . .	. . .	60,800,000	69,600,000	130,400,000
1919—											
January	41,600	25,000	36,200	5,400	0	0	68 0	113.0	1,900,000	500,000	2,100,000
February	360,800	25,000	53,600	43,700	0	0	126 0	181.0	5,300,000	6,300,000	11,600,000
March	314,400	288,500	61,500	61,500	0	124,900	181.5	226.5	8,600,000	10,700,000	19,300,000
April	561,700	355,000	59,500	59,500	2,000	440,700	183 0	228 0	8,400,000	10,400,000	18,800,000
May	593,700	355,000	61,500	61,500	2,800	467,900	183 0	228.0	8,600,000	10,800,000	19,400,000
June	95,500	355,000	59,500	59,500	3,400	15,700	181 0	226 0	8,300,000	10,300,000	18,600,000
July	16,500	312,400	61,500	61,500	3,500	0	165 0	210 0	7,800,000	9,900,000	17,700,000
August	8,500	202,400	61,500	61,500	2,200	0	133 5	178.5	6,300,000	8,400,000	14,700,000
September	8,000	85,700	23,700	13,600	900	0	87 5	139.0	1,700,000	4,600,000	6,300,000
October	9,800	25,500	9,800	0	300	0	68 5	.	500,000	0	500,000
November	9,000	25,200	9,000	0	200	0	68.0		500,000	0	500,000
December	42,300	25,000	38,400	3,900	0	0	68 0	113 0	2,000,000	100,000	2,100,000
Totals	2,061,800	. . .	535,700	461,600	15,300	1,049,200	. . .	. . .	59,900,000	72,300,000	132,200,000
1920—											
January	38,900	25,000	58,200	700	0	0	68 0	113.0	2,000,000	100,000	2,100,000
February	37,400	25,000	36,200	1,200	0	0	68 0	113.0	1,900,000	100,000	2,000,000
March	238,000	25,000	61,500	61,500	0	0	105 0	150 0	5,000,000	7,100,000	12,100,000
April	361,000	140,000	59,500	59,500	900	26,100	160.0	205 0	7,300,000	9,400,000	16,700,000
May	438,000	355,000	61,500	61,500	2,800	313,100	183.0	228 0	8,600,000	10,800,000	19,400,000
June	161,900	355,000	59,500	59,500	3,400	52,500	182 5	227 5	8,400,000	10,400,000	18,800,000
July	33,600	342,000	61,500	61,500	3,800	0	172.5	217 5	8,200,000	10,300,000	18,500,000
August	10,900	248,800	61,500	61,500	2,700	0	148 5	193 5	7,000,000	9,200,000	16,200,000
September	9,300	134,000	57,700	58,900	1,200	0	106.5	151 5	1,800,000	6,900,000	11,700,000
October	31,700	25,500	34,500	200	300	0	68 0	113.0	1,800,000	0	1,800,000
November	152,400	25,200	47,600	37,200	200	0	83 5	137 5	3,200,000	4,000,000	7,200,000
December	272,000	92,600	61,500	61,500	0	0	137 5	182.5	6,500,000	8,600,000	15,100,000
Totals	1,789,000	. . .	640,700	524,700	15,300	391,700	. . .	. . .	64,700,000	76,900,000	141,600,000

With Flood Control

Maximum controlled flow at Fairoaks 100,000 second-feet. Maximum reservoir space required 175,000 acre-feet. Reservoir space held in reserve for flood control from December 1 to May 1 when total precipitation up to any date in a season is more than 50 per cent of the normal precipitation to same date. Flood control reserve increased at a uniform rate from zero on December 1 to 175,000 acre-feet on January 1; 175,000 acre-feet held in reserve from January 1 to April 1 and then decreased at uniform rate to zero on May 1

Year and Month	Stage of reservoir at beginning of month in acre-feet	Power draft through turbines in acre-feet		Evaporation in acre-feet	Release through flood control outlets in acre-feet	Waste over spillway in acre-feet	Average power head in feet		Power yield in kilowatt hours		
		Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet				Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Total
1917—											
January	29,100	61,300	38,800	0	0	0	72.0	117.5	3,400,000	3,600,000	7,000,000
February	26,500	58,000	46,300	0	149,400	0	88 0	133.0	4,000,000	5,000,000	9,000,000
March	180,000	76,200	72,600	0	126,000	0	148 0	193 0	8,600,000	10,800,000	19,400,000
April	180,000	65,500	64,100	1,100	243,500	0	167.0	212 0	8,400,000	10,400,000	18,800 000
May	355,000	61,500	61,500	2,800	0	507,400	183.0	228.0	8,600,000	10,800,000	19,400,000
June	355,000	59,500	59,500	3,400	0	408,100	183.0	228 0	8,400,000	10,400,000	18,800,000
July	355,000	61,500	61,500	4,000	0	12,800	181.5	226.5	8,600,000	10,700,000	19,300,000
August	318,500	61,500	61,500	3,400	0	0	167.0	212.0	7,900,000	10,000,000	17,900,000
September	214,900	59,500	59,500	1,800	0	0	139.5	184 5	6,400,000	8,400,000	14,800,000
October	105,900	41,700	49,600	800	0	0	93.5	145.0	3,200,000	5,500,000	8,700,000
November	25,200	10,800	0	200	0	0	68 0	.	600,000	0	600,000
December	25,000	29,400	2,600	0	0	0	68.0	113.0	1,600,000	200,000	1,800,000
Totals	. . .	646,400	577,500	17,500	518,900	928,300	. . .	. . .	69,700,000	85,800,000	155,500,000
1918—											
January	25,000	17,400	0	0	0	0	68.0	. . .	900,000	0	900,000
February	25,000	48,100	43,800	0	0	0	89.5	139.5	3,400,000	4,800,000	8,200,000
March	57,100	65,300	61,300	0	60,400	0	124 0	169.0	6,300,000	8,400,000	14,700,000
April	180,000	65,500	64,200	1,100	134,600	0	167.0	212.0	8,400,000	10,400,000	18,800,000
May	355,000	61,500	61,500	2,800	0	181,600	183.0	228.0	8,600,000	10,800,000	19,400,000
June	355,000	59,500	59,500	3,400	0	24.100	182.0	227.0	8,300,000	10,400,000	18,700,000
July	323,500	61,500	61,500	3,700	0	0	167.5	212 5	8,000,000	10,000,000	18,000,000
August	216,700	61,500	61,500	2,400	0	0	137.5	182.5	6,500,000	8,600,000	15,100,000
September	95,600	48,300	45 600	1,000	0	0	89.0	140.0	3,500,000	4,900,000	8,400,000
October	25,400	44,700	13,000	300	0	0	68.0	113.0	2,400,000	1,100,000	3,500,000
November	25,200	45,600	2,300	200	0	0	68 0	113.0	2,400,000	200,000	2,600,000
December	25,000	46,000	1,800	0	0	0	68.0	113.0	2,400,000	200,000	2,600,000
Totals	. . .	624,900	479,000	14,900	195,000	206,000	. . .	. . .	61,100,000	69,800,000	130,900,000
1919—											
January	25,000	36,200	5,400	0	0	0	68.0	113.0	1,900,000	500,000	2,400,000
February	25,000	61,200	49,400	0	95,200	0	119.5	175.5	5,900,000	6,800,000	12,700,000
March	180,000	76,200	72,600	0	165,600	0	148 0	193.0	8,600,000	10,800,000	19,400,000
April	180,000	65,300	64,000	1,200	256,200	0	167 0	212 0	8,400,000	10,400,000	18,800,000
May	355,000	61,500	61,500	2,800	0	467,900	183.0	228.0	8,600,000	10,800,000	19,400.000
June	355,000	59,500	59,500	3,400	0	15,700	181.0	226.0	8,300,000	10,300,000	18,600,000
July	312,400	61,500	61,500	3,500	0	0	165 0	210.0	7,800,000	9,900,000	17,700,000
August	202,400	61,500	61,500	2,200	0	0	133.5	178.5	6,300,000	8,400,000	14,700,000
September	85,700	23,700	43,600	900	0	0	87.5	139.0	1,700,000	4,600,000	6,300.000
October	25,500	9,800	0	300	0	0	68 5	. . .	500,000	0	500,000
November	25,200	9,000	0	200	0	0	68.0	. . .	500,000	0	500,000
December	25,000	38,400	3,900	0	0	0	68.0	113.0	2,000,000	400,000	2,400,000
Totals		563,800	482,900	14,500	517,000	483,600	. . .	. . .	60,500,000	72,900,000	135,400,000
1920—											
January	25,000	38,200	700	0	0	0	68.0	113.0	2,000,000	100,000	2,100,000
February	25,000	36,200	1,200	0	0	0	68.0	113.0	1,900,000	100,000	2,000,000
March	25,000	61,500	61,500	0	0	0	105 0	150.0	5,000,000	7,100,000	12,100,000
April	140,000	60,200	60,100	900	24,800	0	159.5	204.5	7,400,000	9,500,000	16,900,900
May	355,000	61,500	61,500	2,800	0	313,100	183.0	228.0	8,600,000	10,800,000	19,400,000
June	355,000	59,500	59,500	3,400	0	52,500	182.5	227.5	8,400,000	10,400,000	18,800,000
July	342,000	61,500	61,500	3,800	0	0	172.5	217.5	8,200,000	10,300,000	18,500,000
August	248,800	61,500	61,500	2,700	0	0	148.5	193.5	7,000,000	9,200,000	16,200,000
September	134,000	57,700	58,900	1,200	0	0	106.5	151.5	4,800,000	6,900,000	11,700,000
October	25,500	34,500	200	300	0	0	68.0	113.0	1,800,000	0	1,800,00
November	25,200	47,600	37,200	200	0	0	83.5	137.5	3,200,000	4,000,000	7,200,000
December	92,600	63,500	63,100	0	58,000	0	136.5	181.5	6,700,000	8,800,000	15,500,000
Totals	. . .	643,400	526,900	15,300	82,800	365,600	. . .	. . .	65,000,000	77,200,000	142,200,000

Water release for power generation in accord with schedule proposed by American River Hydro-electric Company

Installed capacity of power plant, 35,000 k.v.a. P.F.=0.80 L.F.=1.00

With Flood Control

second-feet. Maximum reservoir space required 175,000 acre-feet. Reservoir space held in reserve for flood control from to any date in a season is more than 50 per cent of the normal precipitation to same date. Flood control reserve increased 75,000 acre-feet on January 1; 175,000 acre-feet held in reserve from January 1 to April 1 and then decreased at uniform

aporation acre-feet	Release through flood control outlets in acre-feet	Waste over spillway in acre-feet	Average power head in feet		Power yield in kilowatt hours		
			Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Total
0	0	0	78.0	123.5	3,700,000	4,800,000	8,500,000
0	319,800	0	134.0	179.0	7,000,000	8,900,000	15,900,000
0	169,900	0	148.0	193.0	8,600,000	10,800,000	19,400,000
1,100	300,500	0	167.0	212.0	8,400,000	10,400,000	18,800,000
2,800	0	477,200	183.0	228.0	8,600,000	10,800,000	19,400,000
3,400	0	135,600	183.0	228.0	8,400,000	10,400,000	18,800,000
4,000	0	500	179.5	224.5	8,500,000	10,600,000	19,100,000
3,100	0	0	161.5	206.5	7,600,000	9,800,000	17,400,000
1,700	0	0	131.0	176.0	6,000,000	8,000,000	14,000,000
600	0	0	90.5	137.5	2,100,000	5,800,000	7,900,000
200	0	0	68.0	....	1,700,000	0	1,700,000
0	0	0	68.5	115.5	2,400,000	800,000	3,200,000
16,900	790,200	613,300	....	....	73,000,000	91,100,000	164,100,000
0	0	0	68.5	119.5	1,700,000	600,000	2,300,000
0	0	0	127.5	172.5	5,700,000	7,700,000	13,400,000
0	42,700	0	148.0	193.0	8,600,000	10,800,000	19,400,000
1,100	168,700	0	166.5	211.5	8,400,000	10,400,000	18,800,000
2,800	0	75,000	183.0	228.0	8,600,000	10,800,000	19,400,000
3,300	0	0	176.0	221.0	8,100,000	10,100,000	18,200,000
3,200	0	0	157.0	202.0	7,400,000	9,600,000	17,000,000
1,900	0	0	118.5	163.5	5,600,000	7,700,000	13,300,000
600	0	0	77.5	126.5	700,000	2,500,000	3,200,000
300	0	0	68.5	....	1,200,000	0	1,200,000
200	0	0	78.0	140.5	2,200,000	2,400,000	4,600,000
0	0	0	146.5	191.5	6,900,000	9,100,000	16,000,000
13,400	211,400	75,000	....	....	65,100,000	81,700,000	146,800,000
0	55,100	0	147.5	192.5	8,500,000	10,600,000	19,100,000
0	635,800	0	148.0	193.0	7,800,000	9,700,000	17,500,000
0	292,300	0	148.0	193.0	8,600,000	10,800,000	19,400,000
1,100	421,300	0	167.0	212.0	8,400,000	10,400,000	18,800,000
2,800	0	475,600	183.0	228.0	8,600,000	10,800,000	19,400,000
3,400	0	290,000	183.0	228.0	8,400,000	10,400,000	18,800,000
4,000	0	0	179.0	224.0	8,400,000	10,600,000	19,000,000
3,200	0	0	164.0	209.0	7,700,000	9,900,000	17,600,000
1,700	0	0	136.5	181.5	6,200,000	8,300,000	11,500,000
....	....	....	....	....	....	....	....
....	....	....	....	....	....	....	....
16,200	1,404,500	765,600	....	....	72,600,000	91,500,000	164,100,000
366,800	20,861,800	16,284,500	....	....	1,642,000,000	2,022,300,000	3,664,300,000
16,100	917,000	715,800	....	....	72,200,000	88,900,000	161,100,000

TABLE 51. (Continued). POWER OUTPUT OF FOLSOM PLANT WITH AND WITHOUT FLOOD CONTROL

Folsom reservoir operated primarily for power generation
Auburn and Coloma reservoirs not constructed

Monthly Summary of Computations Carried out on a Daily Basis
(For corresponding yearly summary, see Table 50)

Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet

Measured daily flows at Fairoaks gaging station of United States Geological Survey used in computations

Water release for power generation in accord with schedule proposed by American River Hydro-electric Company
Installed capacity of power plant, 35,000 k.v.a. P.F.=0.80 L.F.=1.00

Without Flood Control

Year and Month	Measured run-off at Fairoaks in acre-feet	Stage of reservoir at beginning of month in acre-feet	Power draft through turbines in acre-feet		Evaporation in acre-feet	Waste over spillway in acre-feet	Average power head in feet		Power yield in kilowatt hours		
			Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet			Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Total
1921—											
January	473,400	241,600	61,500	61,500	0	237,000	178.0	223.0	8,400,000	10,600,000	19,000,000
February	315,600	355,000	55,500	55,500	0	204,600	183.0	228.0	7,800,000	9,700,000	17,500,000
March	534,300	355,000	61,500	61,500	0	411,300	183.0	228.0	8,600,000	10,800,000	19,400,000
April	431,600	355,000	59,500	59,500	2,000	310,600	183.0	228.0	8,400,000	10,400,000	18,800,000
May	526,700	355,000	61,500	61,500	2,800	400,900	183.0	228.0	8,600,000	10,800,000	19,400,000
June	371,500	355,000	59,500	59,500	3,400	249,100	183.0	228.0	8,400,000	10,400,000	18,800,000
July	76,300	355,000	61,500	61,500	4,000	3,100	180.0	225.0	8,500,000	10,700,000	19,200,000
August	20,300	301,200	81,500	61,500	3,200	0	163.0	208.0	7,700,000	9,800,000	17,500,000
September	14,600	195,300	59,500	59,500	1,700	0	133.5	178.5	6,100,000	8,200,000	14,300,000
October	24,500	89,200	38,800	49,000	700	0	89.0	139.0	2,700,000	5,200,000	7,900,000
November	46,700	25,200	40,000	6,700	200	0	68.0	113.0	2,100,000	600,000	2,700,000
December	135,600	25,000	60,500	39,100	0	0	74.5	120.0	3,500,000	3,700,000	7,200,000
Totals	2,971,100	....	680,800	638,300	18,000	1,816,600	....	....	80,800,000	100,900,000	181,700,000
1922—											
January	117,700	61,000	61,500	61,500	0	0	107.5	152.5	5,100,000	7,200,000	12,300,000
February	371,300	55,700	55,500	55,500	0	0	130.0	175.0	5,500,000	7,500,000	13,000,000
March	338,000	316,000	61,500	61,500	0	176,000	182.5	227.5	8,600,000	10,800,000	19,400,000
April	487,400	355,000	59,500	59,500	2,000	366,400	183.0	228.0	8,400,000	10,400,000	18,800,000
May	1,017,500	355,000	61,500	81,500	2,800	891,700	183.0	228.0	8,600,000	10,800,000	19,400,000
June	670,400	355,000	59,500	59,500	3,400	548,000	183.0	228.0	8,400,000	10,400,000	18,800,000
July	98,100	355,000	61,500	61,500	4,000	15,700	181.0	226.0	8,600,000	10,700,000	19,300,000
August	22,000	310,400	61,500	61,500	3,300	0	165.5	210.5	7,800,000	10,000,000	17,800,000
September	15,700	206,100	59,500	59,500	1,800	0	137.5	182.5	6,300,000	8,400,000	14,700,000
October	30,600	101,000	55,900	49,800	700	0	92.5	142.0	4,100,000	5,500,000	9,600,000
November	63,300	25,200	44,500	18,800	200	0	70.0	118.5	2,400,000	1,700,000	4,100,000
December	398,800	25,000	57,600	51,900	0	0	130.0	184.5	6,000,000	7,400,000	13,400,000
Totals	3,630,800	....	699,500	662,000	18,200	1,997,800	....	....	79,800,000	100,800,000	180,600,000
1923—											
January	268,200	314,300	61,500	61,500	0	104,500	182.5	227.5	8,600,000	10,800,000	19,400,000
February	175,300	355,000	55,500	55,500	0	64,300	183.0	228.0	7,800,000	9,700,000	17,500,000
March	218,000	355,000	61,500	61,500	0	96,000	183.0	228.0	8,600,000	10,800,000	19,400,000
April	565,800	355,000	59,500	59,500	2,000	444,800	183.0	228.0	8,400,000	10,400,000	18,800,000
May	612,400	355,000	61,500	61,500	2,800	486,600	183.0	228.0	8,600,000	10,800,000	19,400,000
June	278,300	355,000	59,500	59,500	3,400	155,900	183.0	228.0	8,400,000	10,400,000	18,800,000
July	97,200	355,000	61,500	81,500	4,000	11,000	181.5	226.5	8,600,000	10,700,000	19,300,000
August	21,600	314,200	61,500	61,500	3,400	0	166.0	211.0	7,800,000	10,000,000	17,800,000
September	22,500	209,400	59,500	59,500	1,800	0	140.0	185.0	6,400,000	8,500,000	14,900,000
October	39,700	111,100	61,500	61,500	800	0	103.0	148.0	4,900,000	7,000,000	11,900,000
November	27,800	27,000	27,800	1,800	200	0	68.0	114.0	1,500,000	100,000	1,600,000
December	28,000	25,000	28,900	0	0	0	68.0	......	1,400,000	0	1,400,000
Totals	2,355,700	....	659,700	604,800	18,400	1,362,100	....	....	81,000,000	99,200,000	180,200,000
1924—											
January	38,100	25,000	35,500	2,600	0	0	68.0	113.0	1,900,000	200,000	2,100,000
February	115,300	25,000	56,600	45,800	0	0	87.0	135.0	3,800,000	4,800,000	8,600,000
March	54,000	37,900	52,400	14,500	0	0	69.5	119.0	2,800,000	1,400,000	4,200,000
April	118,900	25,000	59,000	48,100	300	0	76.0	122.5	3,500,000	4,500,000	8,000,000
May	91,500	36,500	55,800	44,900	500	0	77.5	125.5	3,400,000	4,300,000	7,700,000
June	12,300	26,800	12,300	0	400	0	70.0	..	700,000	0	700,000
July	1,600	26,400	1,600	0	500	0	69.5	.	100,000	0	100,000
August	1,000	25,900	1,000	0	500	0	68.5	..	100,000	0	100,000
September	1,400	25,400	1,400	0	400	0	68.9		100,000	0	100,000
October	14,400	25,000	12,200	1,900	300	0	68.0	113.0	600,000	200,000	800,000
November	57,400	25,000	41,500	15,700	200	0	70.0	119.0	2,300,000	1,400,000	3,700,000
December	98,800	25,000	56,900	23,500	0	0	70.0	116.0	3,100,000	2,100,000	5,200,000
Totals	604,700	....	386,200	197,000	3,100	0	....	....	22,400,000	18,900,000	41,300,000

With Flood Control

Maximum controlled flow at Fairoaks 100,000 second-feet. Maximum reservoir space required 175,000 acre-feet. Reservoir space held in reserve for flood control from December 1 to May 1 when total precipitation up to any date in a season is more than 50 per cent of the normal precipitation to same date. Flood control reserve increased at a uniform rate from zero on December 1 to 175,000 acre-feet on January 1; 175,000 acre-feet held in reserve from January 1 to April 1 and then decreased at uniform rate to zero on May 1

Year and Month	Stage of reservoir at beginning of month in acre-feet	Power draft through turbines in acre-feet		Evaporation in acre-feet	Release through flood control outlets in acre-feet	Waste over spillway in acre-feet	Average power head in feet		Power yield in kilowatt hours		
		Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 182 feet				Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Upper unit, tailrace elevation 207 feet	Lower unit, tailrace elevation 162 feet	Total
1921—											
January	180,000	76,200	72,600	0	324,600	0	148.0	193.0	8,600,000	10,800,000	19,400,000
February	180,000	68,800	65,500	0	181,300	0	148.0	193.0	7,800,000	9,700,000	17,500,000
March	180,000	76,200	72,600	0	385,500	0	148.0	193.0	8,600,000	10,800,000	19,400,000
April	180,000	65,400	64,100	1,100	126,000	0	167.0	212.0	8,400,000	10,400,000	18,800,000
May	355,000	61,500	61,500	2,800	0	400,900	183.0	228.0	8,600,000	10,800,000	19,400,000
June	355,000	59,500	59,500	3,400	0	249,100	183.0	228.0	8,400,000	10,400,000	18,800,000
July	355,000	61,500	61,500	4,000	0	3,100	180.0	225.0	8,500,000	10,700,000	19,200,000
August	301,200	61,500	61,500	3,200	0	0	163.0	208.0	7,700,000	9,800,000	17,500,000
September	195,300	59,500	59,500	1,700	0	0	133.5	178.5	6,100,000	8,200,000	14,300,000
October	89,200	38,800	49,000	700	0	0	89.0	139.0	2,700,000	5,200,000	7,900,000
November	25,200	40,000	6,700	200	0	0	68.0	113.0	2,100,000	600,000	2,700,000
December	25,000	60,500	39,100	0	0	0	74.5	120.0	3,500,000	3,700,000	7,200,000
Totals	....	729,400	673,100	17,100	1,017,400	653,100	....	....	81,000,000	101,100,000	182,100,000
1922—											
January	61,000	61,500	61,500	0	0	0	107.5	152.5	5,100,000	7,200,000	12,300,000
February	55,700	60,300	59,200	0	127,500	0	123.5	168.5	5,800,000	7,800,000	13,600,000
March	180,000	76,200	72,600	0	189,200	0	148.0	193.0	8,600,000	10,800,000	19,400,000
April	180,000	65,400	64,100	1,100	181,800	0	167.0	212.0	8,400,000	10,400,000	18,800,000
May	355,000	61,500	61,500	2,800	0	891,700	183.0	228.0	8,600,000	10,800,000	19,400,000
June	355,000	59,500	59,500	3,400	0	548,000	183.0	228.0	8,400,000	10,400,000	18,800,000
July	355,000	61,500	61,500	4,000	0	15,700	181.0	226.0	8,600,000	10,700,000	19,300,000
August	310,400	61,500	61,500	3,300	0	0	165.5	210.5	7,800,000	10,000,000	17,800,000
September	206,100	59,500	59,500	1,800	0	0	137.5	182.5	6,300,000	8,400,000	14,700,000
October	101,000	55,900	49,800	700	0	0	92.5	142.0	4,100,000	5,500,000	9,600,000
November	25,200	44,500	18,800	200	0	0	70.0	118.5	2,400,000	1,700,000	4,100,000
December	25,000	61,700	55,000	0	127,100	0	125.5	179.0	6,200,000	7,700,000	13,900,000
Totals	....	729,000	684,500	17,300	625,600	1,455,400	....	....	80,300,000	101,400,000	181,700,000
1923—											
January	180,000	76,200	72,600	0	119,400	0	148.0	193.0	8,600,000	10,800,000	19,400,000
February	180,000	68,800	65,500	0	41,000	0	148.0	193.0	7,800,000	9,700,000	17,500,000
March	180,000	76,200	72,600	0	69,200	0	148.0	193.0	8,600,000	10,800,000	19,400,000
April	180,000	65,300	64,000	1,100	260,400	0	167.0	212.0	8,400,000	10,400,000	18,800,000
May	355,000	61,500	61,500	2,800	0	486,600	183.0	228.0	8,600,000	10,800,000	19,400,000
June	355,000	59,500	59,500	3,400	0	155,900	183.0	228.0	8,400,000	10,400,000	18,800,000
July	355,000	61,500	61,500	4,000	0	11,000	181.5	226.5	8,600,000	10,700,000	19,300,000
August	314,200	61,500	61,500	3,400	0	0	166.0	211.0	7,800,000	10,000,000	17,800,000
September	209,400	59,500	59,500	1,800	0	0	149.0	185.0	6,400,000	8,500,000	14,900,000
October	111,100	61,500	61,500	800	0	0	103.0	148.0	4,900,000	7,000,000	11,900,000
November	27,000	27,800	1,800	200	0	0	68.0	114.0	1,500,000	100,000	1,600,000
December	25,000	28,900	0	0	0	0	68.0	.	1,400,000	0	1,400,000
Totals	....	708,200	641,500	17,500	490,000	653,500	....	....	81,000,000	99,200,000	180,200,000
1924—											
January	25,000	35,500	2,600	0	0	0	68.0	113.0	1,900,000	200,000	2,100,000
February	25,000	56,600	45,800	0	0	0	87.0	135.0	3,800,000	4,800,000	8,600,000
March	37,900	52,400	14,500	0	0	0	69.5	119.0	2,800,000	1,400,000	4,200,000
April	25,000	59,000	48,100	300	0	0	76.0	122.5	3,500,000	4,500,000	8,000,000
May	38,500	55,800	44,900	500	0	0	77.5	125.5	3,400,000	4,300,000	7,700,000
June	26,800	12,300	0	400	0	0	70.0	.	700,000	0	700,000
July	28,400	1,600	0	500	0	0	69.5		100,000	0	100,000
August	25,900	1,000	0	500	0	0	68.5	.	100,000	0	100,000
September	25,400	1,400	0	400	0	0	68.0	...	100,000	0	100,000
October	25,000	12,200	1,900	300	0	0	68.0	113.0	600,000	200,000	800,000
November	25,000	41,500	15,700	200	0	0	70.0	119.0	2,300,000	1,400,000	3,700,000
December	25,000	56,900	23,500	0	0	0	70.0	116.0	3,100,000	2,100,000	5,200,000
Totals	....	386,200	197,000	3,100	0	0	....	....	22,400,000	18,900,000	41,300,000

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TABLE 51. (Continued). POWER OUTPUT OF FOLSOM PLANT WITH AND WITHOUT FLOOD CONTROL

Folsom reservoir operated primarily for power generation
Auburn and Coloma reservoirs not constructed

Monthly Summary of Computations Carried out on a Daily Basis
(For corresponding yearly summary, see Table 50)

Measured daily flows at Fairoaks gaging station of United States Geological Survey used in computations

Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet

Water release for power generation in accord with schedule proposed by American River Hydro-electric Company

Installed capacity of power plant, 35,000 k.v.a. P.F.=0.80 L.F.=1.00

Without Flood Control

Year and Month	Measured run-off at Fairoaks in acre-feet	Stage of reservoir at beginning of month in acre-feet	Power draft through turbines in acre-feet: Upper unit, tailrace elevation 207 feet	Power draft through turbines in acre-feet: Lower unit, tailrace elevation 162 feet	Evaporation in acre-feet	Waste over spillway in acre-feet	Average power head in feet: Upper unit, tailrace elevation 207 feet	Average power head in feet: Lower unit, tailrace elevation 162 feet	Power yield in kilowatt hours: Upper unit, tailrace elevation 207 feet	Power yield in kilowatt hours: Lower unit, tailrace elevation 162 feet	Power yield in kilowatt hours: Total
1925—											
January	94,000	43,400	61,300	49,600	0	0	78.0	123.5	3,700,000	4,800,000	8,500,000
February	604,000	26,500	55,500	55,400	0	164,600	159.5	204 5	6,800,000	8,700,000	15,500,000
March	318,600	355,000	61,500	61,500	0	195,600	183.0	228.0	8,600,000	10,800,000	19,400,000
April	605,900	355,000	59,500	59,500	2,000	484,900	183.0	228.0	8,400,000	10,400,000	18,800,000
May	603,000	355,000	61,500	61,500	2,800	477,200	183.0	228.0	8,600,000	10,800,000	19,400,000
June	258,000	355,000	59,500	59,500	3,400	135,600	183.0	228 0	8,400,000	10,400,000	18,800,000
July	66,500	355,000	61,500	61,500	4,000	500	179.5	224 5	8,500,000	10,600,000	19,100,000
August	19,900	294,000	61,500	61,500	3,100	0	161.5	206.5	7,600,000	9,800,000	17,400,000
September	16,700	187,800	59,500	59,500	1,700	0	131.0	176.0	6,000,000	8,000,000	14,000,000
October	26,900	83,800	30,700	54,200	600	0	90.5	137.5	2,100,000	5,800,000	7,900,000
November	32,200	25,200	32,200	0	200	0	68.0		1,700,000	0	1,700,000
December	54,900	25,000	45,400	9,500	0	0	68.5	115.5	2,400,000	800,000	3,200,000
Totals	2,700,600	......	649,000	593,200	17,800	1,458,400	......	......	72,800,000	90,900,000	163,700,000
1926—											
January	48,700	25,000	32,800	5,900	0	0	68 5	119.5	1,700,000	600,000	2,300,000
February	258,500	35,000	55,500	55,500	0	0	127.5	172.5	5,300,000	7,200,000	12,500,000
March	193,600	182,500	61,500	61,500	0	0	156 5	201.5	7,400,000	9,500,000	16,900,000
April	474,700	253,100	59,500	59,500	1,500	252,300	180 0	225.0	8,200,000	10,300,000	18,500,000
May	197,200	355,000	61,500	61,500	2,800	75,000	183.0	228 0	8,600,000	10,800,000	19,400,000
June	48,300	351,400	59,500	59,500	3,300	0	176.0	221.0	8,100,000	10,100,000	18,200,000
July	15,200	277,400	61,500	61,500	3,200	0	157.0	202.0	7,400,000	9,600,000	17,000,000
August	10,400	166,400	61,500	61,500	1,900	0	118 5	163.5	5,600,000	7,700,000	13,300,000
September	12,300	51,900	12,300	25,800	600	0	77.5	126 5	700,000	2,500,000	3,200,000
October	21,700	25,500	21,700	0	300	0	68 5		1,200,000	0	1,200,000
November	173,900	25,200	33,500	21,800	200	0	78.0	140.5	2,200,000	2,400,000	4,600,000
December	138,200	143,600	61,500	61,500	0	0	146.5	191.5	6,900,000	9,100,000	16,000,000
Totals	1,592,700	......	582,300	535,500	13,800	327,300	......	......	63,300,000	79,800,000	143,100,000
1927—											
January	222,500	158,800	61,500	61,500	0	0	157.5	202.5	7,400,000	9,600,000	17,000,000
February	770,200	258,300	55,500	55,500	0	562,500	180.5	225.5	7,700,000	9,600,000	17,300,000
March	441,000	355,000	61,500	61,500	0	318,000	183.0	228.0	8,600,000	10,800,000	19,400,000
April	726,700	355,000	59,500	59,500	2,000	605,700	183.0	228.0	8,400,000	10,400,000	18,800,000
May	601,400	355,000	61,500	61,500	2,800	475,600	183.0	228 0	8,600,000	10,800,000	19,400,000
June	412,100	355,000	59,500	59,500	3,400	290,000	183.0	228 0	8,400,000	10,400,000	18,800,000
July	76,200	354,700	61,500	61,500	4,000	0	179.0	224 0	8,400,000	10,600,000	19,000,000
August	29,400	303,900	61,500	61,500	3,200	0	164.0	209.0	7,700,000	9,900,000	17,600,000
September	19,000	201,100	59,500	59,500	1,700	0	136.5	181.5	6,200,000	8,300,000	14,500,000
October	......	100,000	......	......	......	......	......	......	......	......	......
November	......	......	......	......	......	......	......	......	......	......	......
December	......	......	......	......	......	......	......	......	......	......	......
Totals	3,293,100	......	541,500	541,500	17,100	2,251,800	......	......	71,400,000	90,400,000	161,800,000
Totals for 1905-27	66,300,800	......	14,471,600	13,048,300	382,200	38,329,700	......	......	1,632,300,000	2,012,700,000	3,645,000,000
Average for 1905-27	2,914,300	......	636,100	573,600	16,800	1,084,600	......	......	71,700,000	88,500,000	160,200,000

With Flood Control

Maximum controlled flow at Fairoaks 100,000 second-feet. Maximum reservoir space required 175,000 acre-feet. Reservoir space held in reserve for flood control from December 1 to May 1 when total precipitation up to any date in a season is more than 50 per cent of the normal precipitation to same date. Flood control reserve increased at a uniform rate from zero on December 1 to 175,000 acre-feet on January 1; 175,000 acre-feet held in reserve from January 1 to April 1 and then decreased at uniform rate to zero on May 1

Year and Month	Stage of reservoir at beginning of month in acre-feet	Power draft through turbines in acre-feet: Upper unit, tailrace elevation 207 feet	Power draft through turbines in acre-feet: Lower unit, tailrace elevation 162 feet	Evaporation in acre-feet	Release through flood control outlets in acre-feet	Waste over spillway in acre-feet	Average power head in feet: Upper unit, tailrace elevation 207 feet	Average power head in feet: Lower unit, tailrace elevation 162 feet	Power yield in kilowatt hours: Upper unit, tailrace elevation 207 feet	Power yield in kilowatt hours: Lower unit, tailrace elevation 162 feet	Power yield in kilowatt hours: Total
1925—											
January	43,400	61,300	49,600	0	0	0	78.0	123.5	3,700,000	4,800,000	8,500,000
February	26,500	66,800	63,900	0	319,800	0	134.0	179.0	7,000,000	8,900,000	15,900,000
March	180,000	76,200	72,500	0	169,900	0	148.0	193.0	8,600,000	10,800,000	19,400,000
April	180,000	65,300	64,000	1,100	300,500	0	167.0	212 0	8,400,000	10,400,000	18,800,000
May	355,000	61,500	61,500	2,800	0	477,200	183.0	228.0	8,600,000	10,800,000	19,400,000
June	355,000	59,500	59,500	3,400	0	135,600	183.0	228.0	8,400,000	10,400,000	18,800,000
July	355,000	61,500	61,500	4,000	0	500	179.5	224.5	8,500,000	10,600,000	19,100,000
August	294,000	61,500	61,500	3,100	0	0	161.5	206 5	7,600,000	9,800,000	17,400,000
September	187,800	59,500	59,500	1,700	0	0	131 0	176.0	6,000,000	8,000,000	14,000,000
October	83,800	30,700	54,200	600	0	0	90.5	137 5	2,100,000	5,800,000	7,900,000
November	25,200	32,200	0	200	0	0	68 0		1,700,000	0	1,700,000
December	25,000	45,400	9,500	0	0	0	68 5	115.5	2,400,000	800,000	3,200,000
Totals	......	681,400	617,200	16,900	790,200	613,300	......	......	73,000,000	91,100,000	164,100,000
1926—											
January	25,000	32,800	5,900	0	0	0	68.5	119.5	1,700,000	600,000	2,300,000
February	35,000	58,000	57,700	0	0	0	127.5	172.5	5,700,000	7,700,000	13,400,000
March	177,800	76,200	72,500	0	42,700	0	148.0	193.0	8,600,000	10,800,000	19,400,000
April	180,000	65,700	64,200	1,100	168,700	0	166.5	211.5	8,400,000	10,400,000	18,800,000
May	355,000	61,500	61,500	2,800	0	75,000	183.0	228 0	8,600,000	10,800,000	19,400,000
June	351,400	59,500	59,500	3,300	0	0	176.0	221 0	8,100,000	10,100,000	18,200,000
July	277,400	61,500	61,500	3,200	0	0	157 0	202.0	7,400,000	9,600,000	17,000,000
August	166,400	61,500	61,500	1,900	0	0	118 5	163.5	5,600,000	7,700,000	13,300,000
September	51,900	12,300	25,800	600	0	0	77 5	126.5	700,000	2,500,000	3,200,000
October	25,500	21,700	0	300	0	0	68.5	. . .	1,200,000	0	1,200,000
November	25,200	33,500	21,800	200	0	0	78.0	140 5	2,200,000	2,400,000	4,600,000
December	143,600	61,500	61,500	0	0	0	146.5	191 5	6,900,000	9,100,000	16,000,000
Totals	.	605,700	553,400	13,400	211,400	75,000	......	......	65,100,000	81,700,000	146,800,000
1927—											
January	158,800	74,800	71,400	0	55,100	0	147.5	192.5	8,500,000	10,600,000	19,100,000
February	180,000	68,900	65,500	0	635,800	0	148.0	193.0	7,800,000	9,700,000	17,500,000
March	180,000	76,200	72,500	0	292,300	0	148.0	193.0	8,600,000	10,800,000	19,400,000
April	180,000	65,300	64,000	1,100	421,300	0	167.0	212.0	8,400,000	10,400,000	18,800,000
May	355,000	61,500	61,500	2,800	0	475,000	183 0	228 0	8,600,000	10,800,000	19,400,000
June	355,000	59,500	59,500	3,400	0	290,000	183 0	228 0	8,400,000	10,400,000	18,800,000
July	354,700	61,500	61,500	4,000	0	0	179.0	224.0	8,400,000	10,600,000	19,000,000
August	303,900	61,500	61,500	3,200	0	0	164.0	209.0	7,700,000	9,900,000	17,600,000
September	201,100	59,500	59,500	1,700	0	0	136.5	181.5	6,200,000	8,300,000	14,500,000
October	100,000	......	......	......	......	......	......	......	......	......	......
November	......	......	......	......	......	......	......	......	......	......	......
December	......	......	......	......	......	......	......	......	......	......	......
Totals	......	588,700	576,000	16,200	1,404,500	765,600	......	......	72,600,000	91,500,000	164,100,000
Totals for 1905-27	......	15,151,100	13,561,600	366,800	20,861,800	16,284,500	......	......	1,642,000,000	2,022,300,000	3,664,300,000
Average for 1905-27	......	666,000	596,100	16,100	917,000	715,800	......	......	72,200,000	88,900,000	161,100,000

TABLE 52. EFFECT OF FLOOD CONTROL ON POWER OUTPUT FROM CONSOLIDATED DEVELOPMENT

Reservoirs operated primarily for power generation with water release to develop maximum primary power 1905-1927

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant,
*43,000 k.v.a. P.F. =0.80 L.F. =0.75
54,000 k.v.a. P.F. =0.80 L.F. =0.75
Tailrace elevation, 200 feet

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant,
66,000 k.v.a. P.F. =0.80 L.F. =0.75

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant,
30,000 k.v.a. P.F. =0.80 L.F. =0.75

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant,
19,000 k.v.a. P.F. =0.80 L.F. =0.75

Webber Creek reservoir—
Height of dam, 90 feet
Installed capacity of power plant,
10,000 k.v.a. P.F. =0.80 L.F. =0.75

Stage of development	Average annual power output in kilowatt hours		Loss in total power output due to inclusion of flood control	
	Without flood control	With flood control Maximum controlled flow 100,000 second-feet measured at Fairoaks gaging station. Maximum reservation for flood control: Folsom reservoir 175,000 acre-feet, Auburn reservoir 200,000 acre-feet, Coloma reservoir 125,000 acre-feet; total 500,000 acre-feet. Reservoir space held in reserve for flood control December 1 to May 1 when total precipitation up to any date in a season is more than 50 per cent of the normal precipitation to same date. Flood control reserve increased at a uniform rate from zero on December 1 to maximum reservation for flood control on January 1; maximum reservation held in reserve from January 1 to April 1 and then decreased at a uniform rate to zero on May 1.	In kilowatt hours	In per cent of average total annual output
Initial development†— Folsom reservoir and power plant	153,700,000	153,700,000	0	0
Second stage of development†— Folsom, Auburn and Pilot Creek reservoirs and power plants....	481,100,000	481,100,000	0	0
Complete development†— Folsom, Auburn, Pilot Creek, Coloma and Webber Creek reservoirs and power plants....	689,500,000	§689,500,000	0	0

*Initial development only.
†Estimates based on average monthly run-off used in preparing estimates of power output set forth in Chapter IV.
§Reduction in annual primary power output 23,600,000 kilowatt hours.

TABLE 53. EFFECT OF FLOOD CONTROL ON POWER OUTPUT FROM CONSOLIDATED DEVELOPMENT

Reservoirs operated primarily for power generation with water release in accord with schedule proposed by American River Hydro-electric Company

1905-1927

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant,
*35,000 k.v.a. P.F. =0.80 L.F. =1.00
45,000 k.v.a. P.F. =0.80 L.F. =1.00
Tailrace elevations, 162 and 207 feet

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant,
82,000 k.v.a. P.F. =0.80 L.F. =0.60

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant,
37,000 k.v.a. P.F. =0.80 L.F. =0.60

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant,
23,000 k.v.a. P.F. =0.80 L.F. =0.60

Webber Creek reservoir—
Height of dam, 90 feet
Installed capacity of power plant,
13,000 k.v.a. P.F. =0.80 L.F. =0.60

Stage of development	Average annual power output in kilowatt hours		Loss in total power output due to inclusion of flood control	
	Without flood control	With flood control Maximum controlled flow 100,000 second-feet measured at Fairoaks gaging station. Maximum reservation for flood control: Folsom reservoir 175,000 acre-feet, Auburn reservoir 200,000 acre-feet, Coloma reservoir 125,000 acre-feet; total 500,000 acre-feet. Reservoir space held in reserve for flood control December 1 to May 1 when total precipitation up to any date in a season is more than 50 per cent of the normal precipitation to same date. Flood control reserve increased at a uniform rate from zero on December 1 to maximum reservation for flood control on January 1; maximum reservation held in reserve from January 1 to April 1 and then decreased at a uniform rate to zero on May 1.	In kilowatt hours	In per cent of average total annual output
Initial development§—				
Folsom reservoir and power plant	160,200,000	161,100,000	‡900,000	‡0.6
Second stage of development†—				
Folsom, Auburn and Pilot Creek reservoirs and power plants...	569,200,000	567,000,000	2,200,000	0.4
Complete development†—				
Folsom, Auburn, Pilot Creek, Coloma and Webber Creek reservoirs and power plants....	773,100,000	764,200,000	8,900,000	1.2

*Initial development only.
†Estimates based on average monthly run-off used in preparing estimates of power output set forth in Chapter IV.
§Estimates based on measured daily flow at Fairoaks gaging station of United States Geological Survey.
‡Gain.

TABLE 54. EFFECT OF FLOOD CONTROL ON IRRIGATION YIELD OF RESERVOIRS OF CONSOLIDATED DEVELOPMENT OPERATED PRIMARILY FOR IRRIGATION

1905-1927

Operation of Folsom City power plant of Pacific Gas and Electric Co. subordinated to the use of reservoirs for irrigation. Allowance for irrigation expansion in near future of foothill agricultural areas

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet

Stage of development	Without flood control				With flood control Maximum controlled flow, 100,000 second-feet measured at Fairoaks gaging station. Maximum reservation for flood control: Folsom reservoir...... 175,000 acre-feet Auburn reservoir...... 200,000 acre-feet Coloma reservoir...... 125,000 acre-feet Total............ 500,000 acre-feet Reservoir space held in reserve for flood control from December 1 to May 1 when total precipitation up to any date in a season is more than 50 per cent of the normal precipitation to same date. Flood control reserve increased at a uniform rate from zero on December 1 to maximum reservation for flood control on January 1; maximum reservation held in reserve from January 1 to April 1 and then decreased at a uniform rate to zero on May 1.			
	Seasonal irrigation yield without deduction for down-stream prior rights, in acre-feet	Deficiency in irrigation supply			Seasonal irrigation yield without deduction for down-stream prior rights, in acre-feet	Deficiency in irrigation supply		
		Year	In acre-feet	In per cent of a perfect seasonal supply		Year	In acre-feet	In per cent of a perfect seasonal supply
Initial development— Folsom reservoir alone	664,000	1919	38,900	5.9	664,000	1919	38,900	5.9
		1924	183,700	27.7		1924	183,700	27.7
		1926	107,800	16.2		1926	107,800	16.2
Totals	...	...	330,400	49.8	...	...	330,400	49.8
Average	...	...	14,400	2.2	...	...	14,400	2.2
Second stage of development— Folsom and Auburn reservoirs	1,250,000	...	...	...	1,250,000	1908	13,100	1.0
		1924	500,500	40.0		1924	500,500	40.0
		1926	96,400	7.7		1926	96,400	7.7
Totals	...	...	596,900	47.7	...	...	610,000	48.7
Average	...	...	25,900	2.1	...	...	26,500	2.1
Complete development— Folsom, Auburn and Coloma reservoirs	1,757,000	...	...	...	1,757,000	1908	97,800	5.6
		...	...	...	...	1912	54,300	3.1
		1913	122,200	7.0		1913	191,600	10.9
		...	...	...		1918	29,800	1.7
		1920	50,900	2.9		1920	73,200	4.2
		1924	725,900	41.3		1924	725,900	41.3
		...	...	...		1926	136,000	7.7
Totals	...	...	899,000	51.2	...	...	1,308,600	74.5
Average	...	...	39,100	2.2	...	...	56,900	3.2

CHAPTER VII

UTILIZATION OF RESERVOIRS OF CONSOLIDATED DEVELOPMENT FOR CONTROL OF SALINITY IN DELTA OF SACRAMENTO AND SAN JOAQUIN RIVERS

Need for salinity control.

During the past several years the need for the prevention of the incursion of salinity into the channels of the delta of the Sacramento and San Joaquin rivers has been apparent. In months of low water flow of these years, due to the decreased flow of the Sacramento and San Joaquin rivers, and for other reasons, salty water from Suisun Bay has been carried by the tides into the many channels of the delta and mixed with the fresh water from which the irrigated lands of the reclaimed islands obtain their water supply. The location and extent of the lands whose water supply contained in excess of 100 parts of chlorine per 100,000 parts of water for a period in 1924, the driest year of record, are shown on Plate II. During this year salty water penetrated the channels of the delta over 20 miles above the mouths of the Sacramento and San Joaquin rivers, rendering the water undesirable for irrigation of a large area for a part of the irrigation season. Although this was the worst condition experienced in the period of record, salinity has encroached beyond Antioch, located near the lower end of the delta area, in every year since 1920.

Methods of salinity control.

Two methods have been proposed for the solution of the salinity problem. One method, comprehending the construction at a strategic point of a physical barrier below the affected area, has been the subject of an intensive study by the United States Bureau of Reclamation in cooperation with the State of California. The results of this study are contained in a report* which sets forth analyses of a barrier at several sites between Suisun and San Francisco bays. A barrier at any one of the sites studied would prevent the incursion of salt water into the area above it, contingent, however, upon some supplemental mountain storage being provided for its operation. The second method comprehends the creation of a natural barrier by the storage of flood waters in mountain reservoirs and their subsequent release at the proper time and in sufficient volume which would be larger than the requirement for the physical barrier, to supplement the low water flow as needed to prevent the encroachment of the salt water.

With the first method salinity would be controlled to the point of location of the barrier, while with the second method, control would appear practicable at least to the lower end of the delta area of the Sacramento and San Joaquin rivers. Salinity control by the first method is not within the scope of this report and, therefore, is not discussed herein. An opportunity would be afforded, however, of utilizing the reservoirs of the consolidated development for salinity control by the second method, if so desired.

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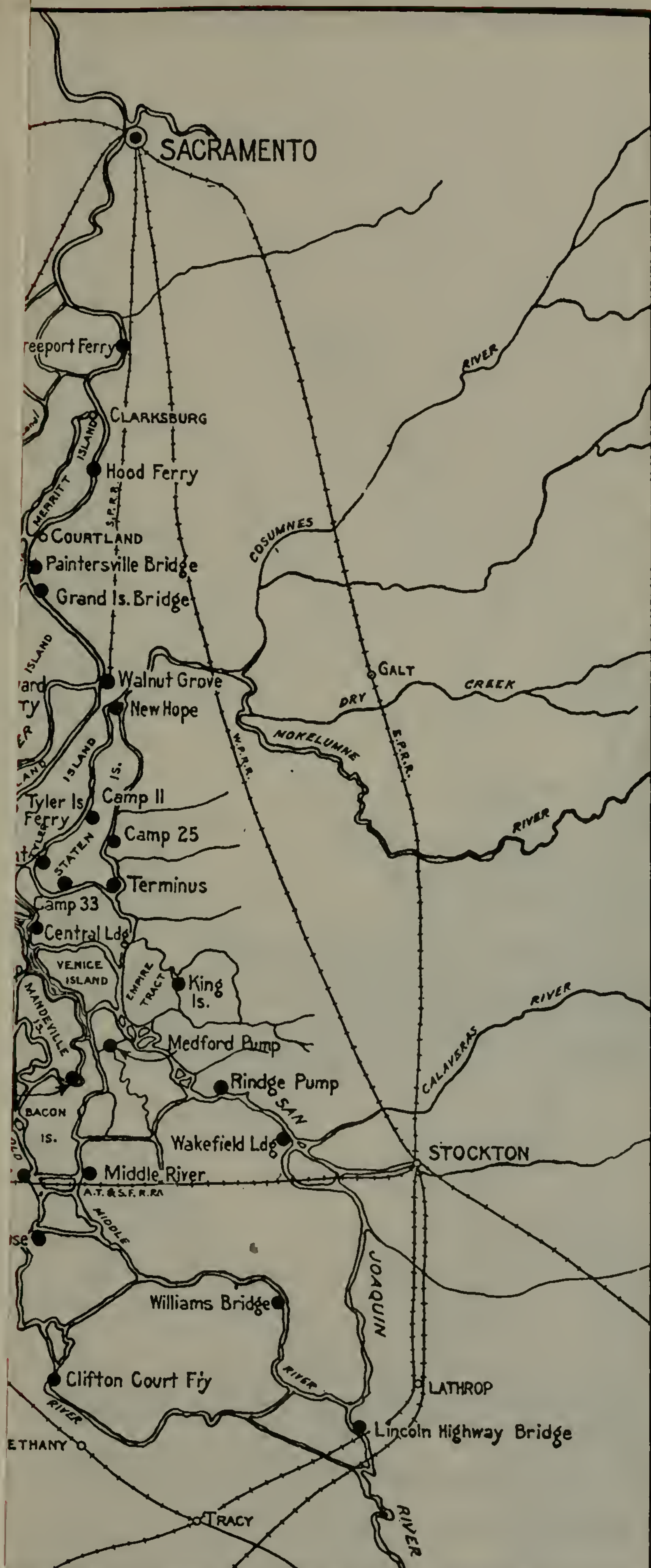
* Bulletin No. 22, Division of Water Resources, "Report on Salt Water Barrier," by Walker R. Young, Engineer U. S. Bureau of Reclamation.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MERRITT ISLAND
Hood Ferry
S.P.R.R.
COURTLAND
Paintersville Bridge
Grand Is. Bridge
ISLAND
Walnut Grove
New Hope
Tyler Is. Ferry
STATEN ISLAND
Camp 11
Camp 25
Terminus
Camp 33
Central Ldg.
VENICE ISLAND
EMPIRE TRACT
King Is.
MANDEVILLE IS.
Medford Pump
Rindge Pump
BACON IS.
Wakefield Ldg.
SAN
Middle River
A.T.&S.F.R.R.
MIDDLE
Williams Bridge
Clifton Court Fry
RIVER
ETHANY
TRACY
JOAQUIN
RIVER
LATHROP
Lincoln Highway Bridge
RIVER
STOCKTON
CALAVERAS
RIVER
W.P.R.R.
E.P.R.R.
GALT
DRY
CREEK
MOKELUMNE
RIVER
COSUMNES
RIVER

CHAPTER VII

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With the first method salinity would be controlled to the point of location of the barrier, while with the second method, control would appear practicable at least to the lower end of the delta area of the Sacramento and San Joaquin rivers. Salinity control by the first method is not within the scope of this report and, therefore, is not discussed herein. An opportunity would be afforded, however, of utilizing the reservoirs of the consolidated development for salinity control by the second method, if so desired.

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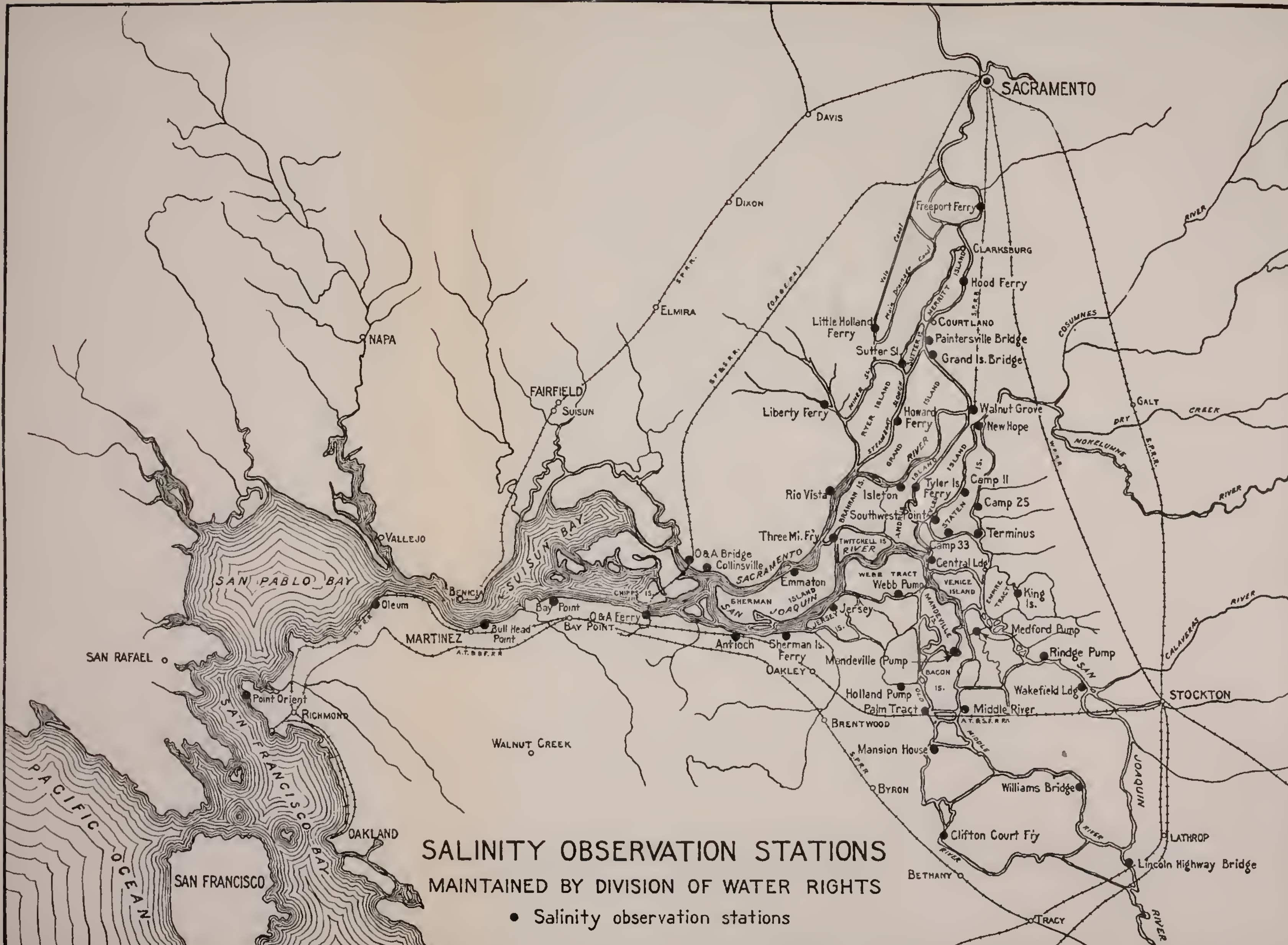
* Bulletin No. 22, Division of Water Resources, "Report on Salt Water Barrier," by Walker R. Young, Engineer U. S. Bureau of Reclamation.



SALINITY OBSERVATION STATIONS
MAINTAINED BY DIVISION OF WATER RIGHTS
• Salinity observation stations

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TABLE 55. LIST OF SALINITY OBSERVATION STATIONS MAINTAINED BY DIVISION OF WATER RIGHTS

Station	Period of observation									
	1919	1920	1921	1922	1923	1924	1925	1926	1927	1928
San Pablo and Suisun Bays										
1. Point Orient								Feb. 10 to Dec. 31	Jan. 1 to Dec. 31	Jan. 1 to Dec. 31
2. Oleum								Feb. 6 to Dec. 31	Jan. 1 to Dec. 31	Jan. 1 to Dec. 31
3. Bull Head Point								Feb. 2 to Dec. 31	Jan. 1 to Dec. 31	Jan. 1 to Dec. 31
4. Bay Point								Feb. 2 to Dec. 31	Jan. 1 to Dec. 31	Jan. 1 to Dec. 31
5. O. and A. Ferry		June 2 to Dec. 2	July 1 to Dec. 30	Sept. 6 to Dec. 14	June 24 to Nov. 30	May 24 to Dec. 30	May 12 to Dec. 31	Jan. 1 to Dec. 31	Jan. 1 to Dec. 31	Jan. 1 to Dec. 31
Sacramento River Delta										
6. O. and A. bridge across Montezuma Slough		June 16 to Nov. 19	July 1 to Dec. 31	Sept. 8 to Dec. 14	June 24 to Nov. 30					
7. Collinsville	Sept. 13 to Sept. 19	June 2 to Nov. 25	July 1 to Dec. 7	Aug. 26 to Nov. 30	June 24 to Nov. 28	May 28 to Dec. 30	May 10 to Dec. 31	Jan. 1 to Dec. 31	Jan. 1 to Dec. 31	Jan. 1 to Dec. 31
8. Emmaton	Sept. 14 to Sept. 19	June 4 to Oct. 6	Aug. 6 to Sept. 13	Sept. 20 to Nov. 16	June 24 to Oct. 6	June 14 to Dec. 18	July 10 to Nov. 28	June 18 to Dec. 14	Aug. 1 to Sept. 10	June 18 to Dec. 30
9. Three Mile Ferry		June 2 to Oct. 31	Aug. 7 to Oct. 27		July 2 to Oct. 30	June 14 to Dec. 6	July 24 to Dec. 26	June 10 to Dec. 22	Aug. 1 to Nov. 26	June 18 to Dec. 30
10. Rio Vista	Sept. 13 to Sept. 10	July 23 to Oct. 9		Sept. 22 to Oct. 16	Aug. 22 to Nov. 16	June 16 to Nov. 20	July 28 to Oct. 24	June 10 to Nov. 22	Aug. 1 to Nov. 18	July 18 to Nov. 6
11. Isleton		Aug. 14 to Sept. 28				July 2 to Nov. 20	Aug. 4 to Nov. 6	June 30 to Oct. 18		Aug. 14 to Nov. 6
12. Liberty Ferry						Aug. 4 to Nov. 14	Aug. 22 to Dec. 6	July 10 to Nov. 10		Aug. 26 to Oct. 26
13. Howard Ferry						July 30 to Oct. 26		July 22 to Oct. 22		
14. Sutter Slough						July 26 to Oct. 30				
15. Little Holland Ferry						Aug. 10 to Oct. 2				
16. Walnut Grove		Aug. 14 to Nov. 1				July 18 to Cct. 24		Aug. 19 to Nov. 26		
17. Grand Island Bridge						Aug. 6 to Oct. 30				
18. Paintersville Bridge								Aug. 18 to Nov. 18		
19. Hood Ferry						Aug. 10 to Oct. 28				
20. Freeport Ferry						Aug. 16 to Oct. 6				
Mokelumne River Delta										
21. Southwest Point								July 14 to Dec. 2		July 18 to Nov. 30
22. Camp 33						July 22 to Dec. 16		July 14 to Dec. 2		July 18 to Nov. 30
23. Tyler Island Ferry		Aug. 14 to Oct. 30				July 30 to Oct. 14		July 22 to Oct. 22		
24. Camp 11						July 22 to Dec. 16		July 14 to Dec. 2		
25. Terminous		Sept. 18 to Nov. 19						July 14 to Dec. 2		Aug. 14 to Nov. 26
26. Camp 25						July 30 to Dec. 16		July 14 to Nov. 22		
27. Newhope Bridge		Aug. 26 to Nov. 19						July 30 to Nov. 22		
San Joaquin River Delta										
28. Antioch	Sept. 14 to Sept. 19	June 3 to Nov. 22	July 5 to Nov. 28	Aug. 26 to Nov. 28	June 28 to Nov. 16	May 24 to Dec. 30	May 2 to Dec. 31	Jan. 1 to Dec. 31	Jan. 1 to Dec. 31	Jan. 1 to Dec. 31
29. Sherman Island Ferry		June 2 to Sept. 30	Aug. 6 to Oct. 31							
30. Jersey	Sept. 13 to Sept. 18	June 2 to Dec. 14	Aug. 6 to Oct. 31	Sept. 16 to Nov. 10	June 28 to Nov. 20	May 22 to Nov. 14	July 10 to Dec. 28	June 10 to Dec. 22	Aug. 2 to Nov. 22	June 18 to Dec. 30
31. Central Landing	Sept. 13 to Sept. 15	July 22 to Nov. 11		Sept. 2 to Nov. 16	June 28 to Aug. 22	June 22 to Dec. 22	Aug. 6 to Nov. 14	July 10 to Dec. 10		July 22 to Oct. 30
32. Webb Pump		July 23 to Dec. 13				July 16 to Nov. 18	July 20 to Dec. 30	June 10 to Dec. 22	Aug. 6 to Nov. 26	June 22 to Dec. 10
33. Mandeville Pump								July 10 to Dec. 10		July 22 to Oct. 22
34. Medford Pump						July 18 to Nov. 20	Aug. 4 to Nov. 6			
35. King Island						Aug. 12 to Dec. 26		Sept. 22 to Nov. 26		Aug. 18 to Oct. 30
36. Rindge Pump						Aug. 8 to Dec. 30	Aug. 12 to Dec. 28	July 26 to Dec. 22		Aug. 14 to Nov. 30
37. Holland Pump						July 26 to Dec. 26	Aug. 6 to Dec. 28	July 2 to Dec. 14		July 18 to Nov. 10
38. Palm Tract								Aug. 6 to Dec. 22		July 18 to Nov. 6
39. Middle River						Aug. 8 to Dec. 31	Aug. 12 to Nov. 30	June 30 to Dec. 26		July 18 to Oct. 30
40. Wakefield Landing		Aug. 7				Aug. 18 to Dec. 22				
41. Mansion House						Aug. 6 to Dec. 10	Aug. 12 to Dec. 28	July 22 to Dec. 28		Aug. 14 to Nov. 2
42. Clifton Court Ferry						Aug. 20 to Nov. 14		Aug. 18 to Oct. 10		
43. Williams Bridge						Aug. 20 to Oct. 20		Aug. 18 to Nov. 18		
44. Lincoln Highway						Sept. 8 to Dec. 2				

Data available on salinity conditions.

The Division of Water Rights has collected and compiled data pertaining to salinity conditions in the delta area for the past ten years and in Suisun and San Pablo bays for the past three years. Its operations commenced in 1919 with observations at six stations in the delta covering a period of only a few days in September. Since that time its activities have increased. In 1924 observations were obtained at 32 stations, in 1926 at 38 stations and in 1928 at 25 stations; and during the period of ten years, observations have been obtained at more than 50 stations. Beginning with the year 1926, data were obtained at 5 stations on Suisun and San Pablo bays. For the most of the stations the period of observation includes only the months during which salinity occurs and, in general, extends over a period of two to six months. Since 1926, however, records at 7 representative stations have been obtained for the entire year. In Table 55 are set forth the principal stations at which observations have been taken since 1919, together with the period of observation in each season. The locations of these stations are shown on Plate VII, "Salinity Observation Stations."

In the determination of the salinity content at the several salinity observation stations, effort was made to obtain samples which would be representative of salinity conditions throughout the delta. Samples were taken at the same predetermined dates at all the stations from one and one-half to two hours following high tide, it having been found after a series of tests that the maximum salinity condition occurred at about this stage of the tidal cycle. Samples were obtained at a depth of about one foot below the surface of the water and well out into the stream channel.

The Division of Water Rights has also collected and compiled data on the fresh water inflow into the delta area. Due to the difficulty, because of tidal action, in obtaining measurements of the fresh water flow of the Sacramento and San Joaquin rivers near their mouths, the Division has estimated * for the four years prior to 1924, and measured since 1924, the flow of the Sacramento River at Sacramento and the San Joaquin at Vernalis, located about 20 miles south of the city of Stockton, during the summer and fall months of each year. Since the contributions to fresh water inflow from other sources below these points are negligible in total during the period of salinity in each season, the combined discharges at these points have been used as the inflow into the delta area in the salinity control studies.

This information has furnished the basis for making an estimate of the supplemental flow that would be required to prevent the encroachment of salinity upstream past certain designated points of control, based on irrigation and channel conditions that have existed in the delta area during the past nine years.

Rate of fresh water inflow into delta required for salinity control.

A study of the relationship of fresh water inflow into the delta of the Sacramento and San Joaquin rivers and the salinity content obtaining at the several stations for the past nine years shows that the rate

* See Bulletin No. 4, "Proceedings of the Second Sacramento-San Joaquin River Problems Conference and Water Supervisors Report," 1924, Division of Water Rights.

of fresh water inflow that would be required for salinity control would vary with the point and the degree of control. To maintain the salinity content to low values would require greater inflows than for higher salinity values with control to the same point. Also, it would require greater inflows to be maintained to control to downstream points in the delta than for higher points for the same degree of control. A study of the data also shows that if salinity were controlled to a particular degree at a specified point, the salinity content at points upstream from the point of control would be less than at the point of control, decreasing progressively upstream.

In the salinity studies contained herein the fresh water inflow into the delta has been maintained at 5000 * second-feet by releasing water from the reservoirs at the proper time and in sufficient volume to meet this demand. The preliminary analysis of the data indicates that this rate of sustained fresh water inflow would control the encroachment of salinity at Antioch to a mean daily salinity of about 100 parts of chlorine per 100,000 parts of water, based on the existing irrigation and channel conditions in the delta area. A wide divergence of opinion is prevalent relative to the degree of salinity control desirable for irrigation. However, with control to 100 parts of chlorine per 100,000 parts of water at Antioch, situated near the lower end of the delta region, the studies show that the salinity content, due to the configuration of the delta area, would decrease upstream to the extent that more than nine-tenths of the delta area above Antioch would have a water supply with a salinity content less than one-third of the content at Antioch.

Supplemental flow required for salinity control.

The total volume of flow that would be required to supplement the natural flow so as to maintain the fresh water inflow into the delta at 5000 second-feet would vary with the season. It has been estimated for the seasons, 1920–1928 inclusive, using combined daily flows of the Sacramento River at Sacramento and the San Joaquin River at Vernalis. During the summer and fall months, contributions to the water supply from other sources are negligible. The volumes of water, so estimated, that would have been required in addition to the natural flow to maintain the combined discharge of the two streams at 5000 second-feet are given in Table 56 for each season of the nine-year period 1920–1928, together with the seasonal run-off from the drainage basins tributary to the delta, expressed in per cent of normal run-off.

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* The rate of inflow of 5000 second feet may be considered as tentative only and may be modified as a result of an intensive investigation of salinity which is now in progress for the 1929 season. This investigation comprehends in addition to the regular salinity observations, that have been made during the past several years, special salinity surveys, stream flow measurements in the delta channels, tidal surveys and detailed analytical studies of the data thus procured from which it is anticipated that definite conclusions as to the behavior of salinity and the relation of salinity to fresh water inflow and to tidal action may be obtained. However, the preliminary estimates of rate and volume of supplementary fresh water inflow as used in this report are believed to be sufficiently accurate for the purpose of estimating reservoir capacities and releases required for salinity control. Since the consumptive use of water in the delta varies from month to month, increasing during the irrigation season, the fresh water inflow necessary to control salinity to any point and degree would have a monthly variation. For the purposes of the study contained herein, a uniform rate of 5000 second feet has been assumed.

TABLE 56. SUPPLEMENTAL FLOW REQUIRED FOR SALINITY CONTROL

Year	Seasonal run-off from drainage basin tributary to delta of Sacramento and San Joaquin rivers, in per cent of normal	Supplemental flow required to maintain inflow of 5,000 second-feet into delta of Sacramento and San Joaquin rivers, in acre-feet
1920	48	*465,000
1921	108	*45,000
1922	97	*30,000
1923	70	*13,000
1924	27	766,000
1925	78	89,000
1926	55	328,000
1927	108	4,000
1928	75	92,000

*Based on estimated stream flow of Sacramento River at Sacramento.

From a study of the data in the foregoing table, it is apparent that in seasons of subnormal run-off, a considerably larger amount of supplemental flow is required than in normal or greater-than-normal years. There are two reasons for this condition. One is that the period of salinity is longer in years of subnormal run-off because the salt water is not forced as far down into Suisun Bay and Carquinez Straits during the months of normally heavy run-off, resulting in a less volume of fresh water to be replaced and, therefore, the salinity arrives at a particular upstream station at an earlier date than for years of normal and greater-than-normal run-off. The other reason is the inflow into the delta in the summer and fall months of years of subnormal run-off is relatively smaller than for corresponding months of years of normal and greater-than-normal run-off, requiring, therefore, a larger supplemental flow during these months.

Salinity control with reservoirs of consolidated development not coordinated with other uses.

In order to furnish the supplemental flow required for salinity control, water must be stored in a reservoir or reservoirs above the delta area and released as needed to meet the requirements for salinity control. In these studies, it is assumed that the inflow into the delta would be maintained at 5000 second-feet, which is estimated would control salinity to about 100 parts of chlorine per 100,000 parts of water at Antioch and meet the present irrigation demands in the delta.

If a reservoir were constructed and operated entirely for salinity control purposes, then the capacity should be equal to the volume of the supplemental flow required in the season of maximum salinity control requirements, increased by the amount of the net annual evaporation from the surface of the reservoir. The reservoir would be kept filled at all times except as water would be released from it to meet the salinity control demands.

If the reservoir of the consolidated development were operated primarily for salinity control purposes in this manner, control could be effected to varying degrees, depending on the stage of development. With the initial development, Folsom reservoir alone, the fresh water inflow into the delta could have been maintained at 5000 second-feet throughout all the years of the period, except 1920 and 1924. In 1920, the inflow would have fallen to 4800 and 2500 second-feet in August, and September, respectively, and in 1924 it would have been 2700, 1800 and 3100 second-feet in July, August and September, respectively. It is apparent, therefore, that salinity control can not be obtained from Folsom reservoir alone even if operated primarily for that purpose, predicated on the maintaining an inflow of 5000 second-feet into the delta. With the second stage of development, Folsom and Auburn reservoirs, and the third stage, Folsom, Auburn and Coloma reservoirs, however, the 5000 second-feet of inflow could have been maintained throughout all of the years of salinity record.

Salinity control with reservoirs of consolidated development coordinated with other uses.

It is apparent that if the reservoirs of the consolidated development were operated entirely for salinity control purposes and were kept filled at all times except as water would be released for salinity control, no reliable flood control and irrigation values would be obtained from the reservoirs. The average power output of the power plants, with such a method of reservoir operation, would be less in total and less valuable per kilowatt hour of output, on account of its poor characteristics, than with the reservoirs operated primarily for power.

In order to set forth the possibilities of coordinating the operation of the reservoirs of the consolidated development for the inclusion of salinity control and to determine its effects on other values, studies have been made for several modes of operation. These studies have been confined to an analysis of the reservoirs of the complete development. Three studies have been made for the period 1905–1927. In each study, the fresh water inflow into the delta was maintained at 5000 second-feet for the seasons during which stream flow records of the Sacramento River at Sacramento were available. For other seasons, the total seasonal supplemental flow required for salinity control was estimated from the data of seasons of record, assuming that the supplemental flow required in a season bears a relation to its normality in run-off from the drainage basin tributary to the delta area. The studies are as follows:

1. Reservoirs operated for power generation to develop maximum primary power consistent with salinity control requirements.
2. Reservoirs operated for power generation in accord with schedule of water release proposed by American River Hydro-electric Company, modified to meet salinity control requirements.
3. Reservoirs operated for maximum irrigation yield consistent with salinity control requirements.

In all of the studies, a reserve was held in the reservoirs to meet the salinity control requirements of a year like 1924, and was maintained except as it was needed to be released for salinity control.

In the first study the drawdown in the reservoirs was limited to the levels obtaining in the critical period of July, 1923, to February, 1924, the period which determined the maximum primary power that could be developed and control salinity in 1924, except as water was needed to maintain primary power and for salinity control.

In the second study a total reserve of 797,000 acre-feet was held for salinity control in the reservoirs, the requirement for 1924 with an additional amount for net evaporation losses from the reservoir surfaces. It was distributed among the reservoirs as follows: Folsom reservoir, 135,000 acre-feet; Auburn reservoir, 242,000 acre-feet; and Coloma reservoir, 420,000 acre-feet; and in each case was above the minimum stage allowed for power generation. These reserves were maintained except as they were needed to meet salinity control demands.

In the third study, an irrigation yield was determined which would maintain the required reserve (797,000 acre-feet) for salinity control and not produce a greater average deficiency in the irrigation supply than was obtaind with the reservoirs operated primarily for irrigation.

The results of these studies are compared with similar ones without salinity control in the following seven tables. In Tables 57 and 58, the power output and characteristics of the first study are compared with similar information for the complete consolidated development operated to develop maximum primary power. In Tables 59 and 60, similar comparisons are made for the second study with the reservoirs of the complete consolidated development operated in accord with schedule of water release proposed by the American River Hydro-electric Company. Table 61 sets forth irrigation yields and incidental power outputs of the third study and those for the reservoirs operated primarily for irrigation without salinity control. Tables 62 and 63 give characteristics of the power listed in Table 61 for plant load factors of 0.75 and 1.00, respectively.

TABLE 57. POWER OUTPUT OF COMPLETE CONSOLIDATED DEVELOPMENT WITH AND WITHOUT SALINITY CONTROL

Water release to develop maximum primary power consistent with salinity control requirements

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant,
54,000 k.v.a. P.F. =0.80 L.F. =0.75

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant,
66,000 k.v.a. P.F. =0.80 L.F. =0.75

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant,
30,000 k.v.a. P.F. =0.80 L.F. =0.75

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant,
19,000 k.v.a. P.F. =0.80 L.F. =0.75

Webber Creek reservoir—
Height of dam, 90 feet
Installed capacity of power plant,
10,000 k.v.a. P.F. =0.80 L.F. =0.75

Year	Power output in kilowatt hours	
	Without salinity control Annual primary power output, 524,700,000 kilowatt hours	**With salinity control** Inflow into the delta of the Sacramento and San Joaquin rivers maintained at 5,000 second-feet. Annual primary output 438,000,000 kilowatt hours
1905	674,900,000	629,900,000
1906	776,400,000	761,400,000
1907	825,900,000	811,000,000
1908	619,800,000	589,700,000
1909	809,000,000	780,700,000
1910	705,100,000	652,100,000
1911	752,700,000	710,700,000
1912	608,500,000	558,700,000
1913	642,700,000	594,200,000
1914	734,200,000	684,600,000
1915	724,000,000	666,600,000
1916	776,800,000	747,500,000
1917	693,500,000	663,100,000
1918	599,100,000	572,600,000
1919	623,500,000	566,900,000
1920	636,900,000	625,700,000
1921	726,100,000	677,600,000
1922	694,500,000	653,000,000
1923	716,900,000	670,500,000
1924	541,700,000	516,300,000
1925	621,000,000	575,500,000
1926	617,600,000	600,700,000
*1927	564,500,000	545,400,000
Average	689,500,000	652,900,000

*Partial year, January 1 to October 1.

TABLE 58. CHARACTERISTICS OF POWER OUTPUT FROM COMPLETE CONSOLIDATED DEVELOPMENT WITH AND WITHOUT SALINITY CONTROL

Water release to develop maximum primary power consistent with salinity control requirements 1905-1927

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant,
54,000 k.v.a. P.F. =0.80 L.F. =0.75

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant,
66,000 k.v.a. P.F. =0.80 L F. =0.75

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant,
30,000 k.v.a. P.F. =0.80 L.F. =0.75

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant,
19,000 k.v.a. P.F. =0.80 L.F. =0.75

Webber Creek reservoir—
Height of dam, 90 feet
Installed capacity of power plant,
10,000 k.v.a. P.F. =0.80 L.F. =0.75

Month	State-wide average monthly demand for power in per cent of annual total	Power output without salinity control. Average annual power output, 689,500,000 kilowatt hours					Power output with salinity control. Inflow into the delta of the Sacramento and San Joaquin rivers maintained at 5,000 second-feet. Average annual power output, 652,900,000 kilowatt hours				
		Maximum year, 1907		Minimum year, 1924			Maximum year, 1907		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year	Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	74,000,000	9.0	38,900,000	7.2	4.7	73,800,000	9.1	32,500,000	6.3	4.0
February	6.9	67,200,000	8.1	36,800,000	6.8	4.5	67,200,000	8.3	30,600,000	5.9	3.8
March	7.8	74,300,000	9.0	41,700,000	7.7	5.1	74,300,000	9.2	34,500,000	6.7	4.3
April	7.9	72,000,000	8.7	42,300,000	7.8	5.1	72,000,000	8.9	35,000,000	6.8	4.3
May	8.8	74,400,000	9.0	47,100,000	8.7	5.7	74,400,000	9.2	45,800,000	8.9	5.6
June	9.0	72,000,000	8.7	47,900,000	8.8	5.8	72,000,000	8.9	57,800,000	11.2	7.1
July	9.4	74,300,000	9.0	50,200,000	9.3	6.1	74,300,000	9.2	62,400,000	12.1	7.7
August	9.5	74,200,000	9.0	51,200,000	9.5	6.2	72,600,000	8.9	57,500,000	11.1	7.1
September	8.7	60,300,000	7.3	47,300,000	8.7	5.7	51,300,000	6.3	41,900,000	8.1	5.2
October	8.5	55,100,000	6.7	47,000,000	8.7	5.7	55,500,000	6.8	40,300,000	7.8	5.0
November	8.0	56,100,000	6.8	44,600,000	8.2	5.4	52,200,000	6.4	38,300,000	7.4	4.7
December	8.2	72,000,000	8.7	46,700,000	8.6	5.6	71,400,000	8.8	39,700,000	7.7	4.9
Totals	100.0	825,900,000	100.0	541,700,000	100.0	65.6	811,000,000	100.0	516,300,000	100.0	63.7

TABLE 59. POWER OUTPUT OF COMPLETE CONSOLIDATED DEVELOPMENT WITH AND WITHOUT SALINITY CONTROL

Water release in accord with schedule proposed by American River Hydro-electric Company consistent with salinity control requirements

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant,
45,000 k.v.a. P.F. =0.80 L.F. =1.00

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant,
82,000 k.v.a. P.F. =0.80 L.F. =0.60

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant,
37,000 k.v.a. P.F. =0.80 L.F. =0.60

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant,
23,000 k.v.a. P.F. =0.80 L.F. =0.60

Webber Creek reservoir—
Height of dam, 90 feet
Installed capacity of power plant,
13,000 k.v.a. P.F. =0.80 L.F. =0.60

Year	Power output in kilowatt hours	
	Without salinity control	With salinity control. Inflow into the delta of Sacramento and San Joaquin rivers maintained at 5,000 second-feet
1905	753,100,000	740,500,000
1906	852,600,000	858,200,000
1907	874,400,000	878,200,000
1908	761,100,000	664,200,000
1909	877,000,000	880,900,000
1910	853,300,000	784,900,000
1911	870,600,000	832,600,000
1912	659,400,000	554,200,000
1913	601,300,000	574,000,000
1914	853,100,000	818,000,000
1915	841,700,000	786,700,000
1916	866,700,000	837,800,000
1917	846,700,000	769,400,000
1918	703,300,000	670,800,000
1919	747,300,000	717,000,000
1920	671,700,000	676,200,000
1921	839,900,000	797,800,000
1922	823,100,000	813,600,000
1923	855,600,000	793,300,000
1924	351,600,000	440,200,000
1925	769,900,000	682,500,000
1926	680,500,000	670,500,000
*1927	633,600,000	648,700,000
Average	773,100,000	742,500,000

*Partial year, January 1 to October 1.

TABLE 60. CHARACTERISTICS OF POWER OUTPUT FROM COMPLETE CONSOLIDATED DEVELOPMENT WITH AND WITHOUT SALINITY CONTROL

Water release in accord with schedule proposed by American River Hydro-electric Co. consistent with salinity control requirements

1905-1927

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant,
45,000 k.v a. P.F. =0.80 L.F. =1.00

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant,
82,000 k v.a. P.F. =0.80 L.F. =0 60

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant,
37,000 k.v.a. P.F. =0.80 L.F. =0.60

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant,
23,000 k.v.a. P.F. =0.80 L.F. =0.60

Webber Creek reservoir—
Height of dam, 90 feet
Installed capacity of power plant,
13,000 k.v.a. P.F. =0.80 L.F. =0.60

Month	State-wide average monthly demand for power in per cent of annual total	Power output without salinity control. Average annual power output, 773,100,000 kilowatt hours					Power output with salinity control. Inflow into the delta of the Sacramento and San Joaquin rivers maintained at 5,000 second-feet. Average annual power output, 742,500,000 kilowatt hours				
		Maximum year, 1909		Minimum year, 1924			Maximum year, 1909		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year	Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	67,200,000	7.7	45,800,000	13.0	5.2	71,300,000	8.1	30,500,000	6.9	3.5
February	6.9	69,300,000	7.9	50,400,000	14.4	5.8	69,300,000	7.9	49,900,000	11.3	5.7
March	7.8	76,900,000	8.8	42,200,000	12.0	4.8	76,900.000	8.7	33,600,000	7.6	3.8
April	7.9	74,200,000	8.4	48,200,000	13.7	5.5	74,200,000	8.4	46,200,000	10.5	5.2
May	8.8	76,900,000	8.8	43,900,000	12.5	5.0	76,900,000	8.7	46,900,000	10.6	5.3
June	9.0	74,200,000	8.4	30,700,000	8.7	3.5	74,200,000	8.4	60,600,000	13.8	6.9
July	9.4	76,200,000	8.7	30,400,000	8.7	3.5	76,300,000	8.7	58,300,000	13.3	6.6
August	9.5	75,600,000	8.6	8,900,000	2.5	1.0	75,200,000	8.5	45,000,000	10.2	5.1
September	8.7	71,100,000	8.1	2,900,000	0.8	0.3	71,100,000	8.1	24,900,000	5.7	2.8
October	8.5	71,600,000	8.2	6,400,000	1.8	0.7	71,500,000	8.1	6,900,000	1.6	0.8
November	8.0	69,300,000	7.9	16,600,000	4.7	1.9	69,200,000	7.9	14,500,000	3.3	1.7
December	8.2	74,500,000	8.5	25,200,000	7.2	2.9	74,800,000	8.5	22,900,000	5.2	2.6
Totals	100.0	877,000,000	100.0	351,600,000	100.0	40.1	880,900,000	100.0	440,200,000	100.0	50.0

TABLE 61. IRRIGATION YIELD AND INCIDENTAL POWER OUTPUT OF COMPLETE CONSOLIDATED DEVELOPMENT WITH AND WITHOUT SALINITY CONTROL

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant, 54,000 k.v.a. P.F. =0.80

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant, 66,000 k.v.a. P.F. =0.80

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant, 30,000 k.v.a. P.F. =0.80

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant, 19,000 k.v.a. P.F. =0.80

Webber Creek reservoir—
Height of dam, 90 feet
Installed capacity of power plant, 10,000 k.v.a. P.F. =0.80

Year	Reservoirs operated without salinity control					Reservoirs operated with salinity control Inflow into the delta of the Sacramento and San Joaquin rivers maintained at 5,000 second-feet				
	Seasonal irrigation draft (No deduction for downstream prior rights) in acre-feet	Deficiency in supply		Power output from irrigation draft delivered at tailrace (elevation 200 feet) of Folsom plant in kilowatt hours		Seasonal irrigation draft (No deduction for downstream prior rights) in acre-feet	Deficiency in supply		Power output from irrigation draft delivered at tailrace (elevation 200 feet) of Folsom plant in kilowatt hours	
		In acre-feet	In per cent of perfect supply	Load factor =0.75	Load factor =1.00		In acre-feet	In per cent of perfect supply	Load factor =0.75	Load factor =1.00
1905	1,757,000	0	0	438,000,000	555,900,000	1,070,000	....	....	424,900,000	519,600,000
1906	1,757,000	0	0	527,300,000	679,500,000	1,070,000	....	....	581,500,000	734,600,000
1907	1,757,000	0	0	616,700,000	791,900,000	1,070,000	....	....	669,400,000	817,000,000
1908	1,757,000	0	0	536,200,000	677,400,000	1,070,000	....	....	634,600,000	781,900,000
1909	1,757,000	0	0	715,000,000	925,400,000	1,070,000	....	....	736,400,000	942,700,000
1910	1,757,000	0	0	662,300,000	866,200,000	1,070,000	....	....	662,500,000	843,200,000
1911	1,757,000	0	0	615,100,000	796,700,000	1,070,000	....	....	646,200,000	827,300,000
1912	1,757,000	0	0	418,200,000	524,400,000	1,070,000	....	....	444,200,000	562,400,000
1913	1,634,800	122,200	7	356,100,000	442,900,000	1,070,000	....	....	374,900,000	482,200,000
1914	1,757,000	0	0	620,900,000	798,600,000	1,070,000	....	....	601,100,000	716,000,000
1915	1,757,000	0	0	549,600,000	697,600,000	1,070,000	....	....	555,700,000	700,500,000
1916	1,757,000	0	0	587,900,000	764,900,000	1,070,000	....	....	642,300,000	797,900,000
1917	1,757,000	0	0	532,900,000	686,300,000	1,070,000	....	....	588,200,000	759,300,000
1918	1,757,000	0	0	442,700,000	566,500,000	1,070,000	....	....	437,400,000	572,000,000
1919	1,757,000	0	0	435,800,000	560,000,000	1,070,000	....	....	447,300,000	566,200,000
1920	1,706,100	50,900	3	374,300,000	471,500,000	1,070,000	....	....	396,700,000	506,100,000
1921	1,757,000	0	0	551,200,000	715,000,000	1,070,000	....	....	560,500,000	710,900,000
1922	1,757,000	0	0	480,300,000	614,600,000	1 070,000	....	....	535,600,000	677,400,000
1923	1,757,000	0	0	568,500,000	726,200,000	1,070,000	....	....	652,400,000	809,300,000
1924	1,031,100	725,900	41	215,400,000	264,200,000	529,900	540,100	51	327,900,000	396,900,000
1925	1,757,000	0	0	480,900,000	607,500,000	1,070,000	....	....	469,300,000	591,300,000
1926	1,757,000	0	0	394,100,000	508,300,000	1,070,000	....	....	428,800,000	537,300,000
1927	1,757,000	0	0	*526,200,000	*690,200,000	1,070,000	....	....	*541,300,000	*683,100,000
Average	1,717,900	39,100	2.2	511,900,000	656,400,000	1,046,500	23,500	2.2	543,400,000	685,500,000

*Partial year, January 1 to October 1.

TABLE 62. CHARACTERISTICS OF INCIDENTAL POWER OUTPUT FROM COMPLETE CONSOLIDATED DEVELOPMENT OPERATED FOR IRRIGATION WITH AND WITHOUT SALINITY CONTROL

1905-1927

Load factor = 0.75

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant, 54,000 k.v.a. P.F. = 0.80

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant, 66,000 k.v.a. P.F. = 0.80

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant, 30,000 k.v.a. P.F. = 0.80

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant, 19,000 k.v.a. P.F. = 0.80

Webber Creek reservoir—
Height of dam, 90 feet
Installed capacity of power plant, 10,000 k.v.a. P.F. = 0.80

Month	State-wide average monthly demand for power in per cent of annual total	Power output without salinity control Average annual power output, 511,900,000 kilowatt hours					Power output with salinity control Inflow into the delta of the Sacramento and San Joaquin rivers maintained at 5,000 second-feet Average annual power output, 543,400,000 kilowatt hours				
		Maximum year, 1909		Minimum year, 1924			Maximum year, 1909		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year	Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	73,200,000	10.2	0	0	0	74,400,000	10.1	0	0	0
February	6.9	67,200,000	9.4	0	0	0	67,200,000	9.1	0	0	0
March	7.8	74,400,000	10.4	6,300,000	2.9	0.9	74,400,000	10.1	4,500,000	1.4	0.6
April	7.9	71,900,000	10.1	33,300,000	15.5	4.6	71,900,000	9.8	24,500,000	7.5	3.3
May	8.8	74,400,000	10.4	73,700,000	34.2	10.3	74,400,000	10.1	74,400,000	22.7	10.1
June	9.0	71,900.000	10.1	60,800,000	28.2	8.5	71,900,000	9.8	72,000,000	21.9	9.8
July	9.4	74,300,000	10.4	31,200,000	14.5	4.3	74,300,000	10.1	60,300,000	18.4	8.2
August	9.5	74,300,000	10.4	2,000,000	0.9	0.3	74,300,000	10.1	49,800,000	15.2	6.8
September	8.7	68,500,000	9.6	2,600,000	1.2	0.4	55,500,000	7.5	32,600,000	9.9	4.4
October	8.5	27,400,000	3.8	5,500,000	2.6	0.8	18,900,000	2.6	9,800,000	3.0	1.3
November	8.0	0	0	0	0	0	4,800,000	0.6	0	0	0
December	8.2	37,500,000	5.2	0	0	0	74,400,000	10.1	0	0	0
Totals	100.0	715,000,000	100.0	215,400,000	100.0	30.1	736,400,000	100.0	327,900,000	100.0	44.5

TABLE 63. CHARACTERISTICS OF INCIDENTAL POWER OUTPUT FROM COMPLETE CONSOLIDATED DEVELOPMENT OPERATED FOR IRRIGATION WITH AND WITHOUT SALINITY CONTROL

1905-1927

Load factor = 1.00

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant, 54,000 k.v.a. P.F. =0.80

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant, 66,000 k.v.a. P.F. =0.80

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant, 30,000 k.v.a. P.F. =0.80

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant, 19,000 k.v.a. P.F. =0.80

Webber Creek reservoir—
Height of dam, 90 feet
Installed capacity of power plant, 10,000 k.v.a. P.F. =0.80

Month	State-wide average monthly demand for power in per cent of annual total	Power output without salinity control. Average annual power output, 656,400,000 kilowatt hours					Power output with salinity control. Inflow into the delta of the Sacramento and San Joaquin rivers maintained at 5,000 second-feet. Average annual power output, 685,500,000 kilowatt hours				
		Maximum year, 1909		Minimum year, 1924			Maximum year, 1909		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year	Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	95,900,000	10.4	0	0	0	99,200,000	10.5	0	0	0
February	6.9	89,600,000	9.7	0	0	0	89,600,000	9.5	0	0	0
March	7.8	99,200,000	10.7	6,400,000	2.4	0.7	99,200,000	10.5	4,500,000	1.1	0.5
April	7.9	95,800,000	10.4	33,300,000	12.6	3.6	95,800,000	10.2	24,500,000	6.2	2.6
May	8.8	99,200,000	10.7	93,100,000	35.2	10.1	99,200,000	10.5	97,500,000	24.6	10.3
June	9.0	95,800,000	10.4	81,000,000	30.7	8.7	95,800,000	10.2	96,000,000	24.2	10.2
July	9.4	99,200,000	10.7	40,300,000	15.2	4.3	93,700,000	10.0	71,200,000	17.9	7.6
August	9.5	99,200,000	10.7	2,000,000	0.8	0.2	89,000,000	9.4	57,800,000	14.5	6.1
September	8.7	80,500,000	8.7	2,600,000	1.0	0.3	58,200,000	6.2	35,600,000	9.0	3.8
October	8.5	27,300,000	2.9	5,500,000	2.1	0.6	19,000,000	2.0	9,800,000	2.5	1.0
November	8.0	0	0	0	0	0	4,800,000	0.5	0	0	0
December	8.2	43,700,000	4.7	0	0	0	99,200,000	10.5	0	0	0
Totals	100.0	925,400,000	100.0	261,200,000	100.0	28.5	942,700,000	100.0	396,900,000	100.0	42.1

Salinity control obtainable through operation of reservoirs of consolidated development primarily for power.

It is of interest to determine the amount of salinity control that could be obtained with the reservoirs of the complete consolidated development operated primarily for power generation without water being released especially for salinity control purposes. The period 1920–1927 has been investigated for the reservoirs operated with the two methods of water release, one developing maximum primary power and the other in accord with the schedule proposed by the American River Hydro-electric Company.

It was found that with both schedules of release, the inflow into the delta would have been maintained in excess of 5000 second-feet in all years of the period investigated, except 1920, 1924 and 1926. The values of average inflow for the months of these years, during which the inflow would have fallen below 5000 second-feet together with the natural flow, are given in Table 64.

TABLE 64. INFLOW INTO DELTA OF SACRAMENTO AND SAN JOAQUIN RIVERS WITH RESERVOIRS OF CONSOLIDATED DEVELOPMENT OPERATED PRIMARILY FOR POWER WITH TWO SCHEDULES OF WATER RELEASE FOR MONTHS IN WHICH AVERAGE INFLOW WAS LESS THAN 5,000 SECOND-FEET 1920-1927

Year and month	Inflow into delta (average for month), in second-feet		
	Natural flow	With schedule of water release to develop maximum primary power	With schedule of water release proposed by American River Hydro-electric Company
1920—			
July	3,660	4,790	In excess of 5,000
August	1,550	3,050	3,680
September	2,530	3,980	4,670
1924—			
June	1,900	3,870	4,290
July	1,330	3,390	3,710
August	1,780	3,900	2,050
September	3,120	In excess of 5,000	3,120
1926—			
July	2,650	4,230	4,880
August	2,580	4,320	4,920

CHAPTER VIII

METHODS OF OPERATING THE COMPLETE CONSOLIDATED DEVELOPMENT COORDINATELY FOR FLOOD CONTROL, SALINITY CONTROL, IRRIGATION AND POWER

In the previous chapters there have been given the possibilities of operating the reservoirs of the consolidated development for various purposes, together with the effect of the inclusion of flood control and of salinity control in the operation of the reservoirs on their yields in irrigation and power. It has been shown that the inclusion of the flood control feature has little or no effect on the irrigation and power yield, while salinity control affects the irrigation yield in direct proportion to the amount of reservoir capacity held in reserve for that purpose, but has a lesser effect on the power yield and characteristics due to the fact that the water released for salinity control in seasons of low run-off is available for the generation of power. With a total reservoir capacity of 1,719,000 acre-feet located on the lower reaches of the stream in a position to control a mean annual run-off of about 3,000,000 acre-feet, an opportunity is afforded with the complete development to incorporate at one time into the operation of the reservoirs all four uses that have been analyzed, namely; flood control, salinity control, irrigation and power, and obtain a substantial value for each use.

In order to determine what might be acomplished if the complete consolidated development were operated coordinately for all these purposes, a study has been made through the period 1905–1927 with the reservoirs operated in the following manner:

1. Floods controlled to 100,000 second-feet maximum flow measured at the Fairoaks gaging station of the United States Geological Survey on the American River.
2. Fresh water inflow into the delta of the Sacramento and San Joaquin rivers maintained at 5000 second-feet for salinity control and to meet the irrigation demands of the delta area.
3. An irrigation supply (334,000 acre-feet per season) for San Joaquin Valley.
4. Power generation to develop maximum primary power consistent with other uses.

In controlling floods to 100,000 second-feet maximum flow measured at the Fairoaks gaging station of the United States Geological Survey, the reservoirs were operated in accord with the rule set forth in Chapter VI, by utilizing, at times, a maximum reservation for flood control of 175,000 acre-feet in the Folsom reservoir, 200,000 acre-feet in the Auburn reservoir and 125,000 acre-feet in the Coloma reservoir, an aggregate space of 500,000 acre-feet.

The inflow into the delta area of the Sacramento and San Joaquin rivers was maintained at 5000 second-feet throughout all years of the period investigated to meet the irrigation demands of the delta and for salinity control at Antioch, contemplating control to about 100 parts of chlorine per 100,000 parts of water. To meet the requirements for salinity control, a total of 797,000 acre-feet of stored water above the lowest levels permitted for power generation was held in reserve in the reservoirs and released only as needed for salinity control purposes.

The reservoirs were also operated for an irrigation supply to San Joaquin Valley, amounting to 334,000 acre-feet per season without deficiency in supply, and released at a maximum rate of flow of 1000 second-feet. This was supplied in accord with the monthly irrigation demand for the San Joaquin Valley floor, which is set forth on page 51 of Bulletin No. 6, "Irrigation Requirements of California Lands," published by Division of Engineering and Irrigation, and is as follows:

Month	*Irrigation demand in per cent of seasonal total*
January	0
February	2
March	5
April	11
May	17
June	18
July	18
August	15
September	10
October	4
November	0
December	0
Total	100

The power output that could be obtained from the development operated for the uses described above was estimated for the period 1905–1927. The maximum primary power possible of generation consistent with other uses, and additional secondary power up to the capacity of the generating equipment, were developed, utilizing the same total generator installation, 179,000 k.v.a P.F.=0.80, given in Chapter IV for the method of water release to develop maximum primary power. The power output and characteristics are given in Tables 65 and 66, respectively. The annual primary power output with this method of operation is 340,800,000 kilowatt hours, 183,900,000 kilowatt hours or 35.0 per cent less than the annual primary output for the complete development operating primarily for power generation; however, the average annual total power output is only 57,200,000 kilowatt hours, or 8.3 per cent less than the average total.

TABLE 65. POWER OUTPUT OF COMPLETE CONSOLIDATED DEVELOPMENT OPERATED COORDINATELY FOR FLOOD CONTROL SALINITY CONTROL, IRRIGATION AND POWER

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant, 54,000 k.v.a. P.F. = 0.80
Maximum reservation for flood control, 175,000 acre-feet.
Reservation for salinity control, 135,000 acre-feet

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet.
Installed capacity of power plant, 66,000 k.v.a P.F. = 0.80.
Maximum reservation for flood control, 200,000 acre-feet
Reservation for salinity control, 242,000 acre-feet

Coloma reservoir—
Height of dam, 340 feet.
Capacity of reservoir, 766,000 acre-feet.
Installed capacity of power plant, 30,000 k.v.a P.F. = 0.80.
Maximum reservation for flood control, 125,000 acre-feet.
Reservation for salinity control, 420,000 acre-feet.

Pilot Creek reservoir—
Height of dam, 110 feet.
Installed capacity of power plant, 19,000 k.v.a. P.F. = 0.80.

Webber Creek reservoir—
Height of dam, 90 feet.
Installed capacity of power plant, 10,000 k.v.a P.F. = 0.80.

Floods controlled to 100,000 second-feet maximum flow at Fairoaks
Inflow into the delta of the Sacramento and San Joaquin rivers maintained at 5,000 second-feet for salinity control and to meet the irrigation demands of the delta
Irrigation supply for San Joaquin Valley of 334,000 acre-feet per season (no deficiency in supply), at maximum rate of 1,000 second-feet

Year	Power output in kilowatt hours Load factor = 0.75 Annual primary power output, 340,800,000 kilowatt hours
1905	621,900,000
1906	739,500,000
1907	783,000,000
1908	612,900,000
1909	764,700,000
1910	617,800,000
1911	679,100,000
1912	513,400,000
1913	517,800,000
1914	631,000,000
1915	640,000,000
1916	720,900,000
1917	616,800,000
1918	571,700,000
1919	554,400,000
1920	590,800,000
1921	650,400,000
1922	662,000,000
1923	637,300,000
1924	486,700,000
1925	524,900,000
1926	605,900,000
1927*	519,600,000
Average	632,300,000

*Partial year, January 1 to October 1

TABLE 66. CHARACTERISTICS OF POWER OUTPUT OF COMPLETE CONSOLIDATED DEVELOPMENT OPERATED COORDINATELY FOR FLOOD CONTROL, SALINITY CONTROL, IRRIGATION AND POWER

Folsom reservoir—
- Height of dam, 190 feet.
- Capacity of reservoir, 355,000 acre-feet.
- Installed capacity of power plant, 54,000 k.v.a. P.F. =0.80.
- Maximum reservation for flood control, 175,000 acre-feet.
- Reservation for salinity control, 135,000 acre-feet.

Auburn reservoir—
- Height of dam, 390 feet.
- Capacity of reservoir, 598,000 acre-feet.
- Installed capacity of power plant, 66,000 k.v.a P.F. =0.80.
- Maximum reservation for flood control, 200,000 acre-feet.
- Reservation for salinity control, 242,000 acre-feet.

Coloma reservoir—
- Height of dam, 340 feet.
- Capacity of reservoir, 766,000 acre-feet.
- Installed capacity of power plant, 30,000 k.v.a P.F. =0.80.
- Maximum reservation for flood control, 125,000 acre-feet.
- Reservation for salinity control, 420,000 acre-feet.

Pilot Creek reservoir—
- Height of dam, 110 feet.
- Installed capacity of power plant, 19,000 k.v.a. P.F. =0.80.

Webber Creek reservoir—
- Height of dam, 90 feet.
- Installed capacity of power plant, 10,000 k.v.a. P.F. =0.80.

Floods controlled to 100,000 second-feet maximum flow at Fairoaks

Inflow into the delta of the Sacramento and San Joaquin rivers maintained at 5,000 second-feet for salinity control and to meet the irrigation demand of the delta

Irrigation supply for San Joaquin Valley of 334,000 acre-feet per season (no deficiency in supply), at maximum rate of 1,000 second-feet

Average annual power output, 632,300,000 kilowatt hours

Month	State-wide average monthly demand for power in per cent of annual total	Power output in kilowatt hours Load factor = 0.75				
		Maximum year, 1907		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	74,400,000	9.5	25,000,000	5.1	3.2
February	6.9	67,200,000	8.5	23,800,000	4.9	3.0
March	7.8	74,300,000	9.5	26,700,000	5.5	3.4
April	7.9	72,000,000	9.2	27,000,000	5.6	3.5
May	8.8	74,400,000	9.5	56,900,000	11.7	7.3
June	9.0	72,000,000	9.2	64,300,000	13.2	8.2
July	9.4	74,300,000	9.5	67,700,000	13.9	8.6
August	9.5	69,800,000	8.9	59,400,000	12.2	7.6
September	8.7	54,500,000	7.0	42,800,000	8.8	5.5
October	8.5	39,000,000	5.0	31,600,000	6.5	4.0
November	8.0	42,400,000	5.4	30,200,000	6.2	3.9
December	8.2	68,700,000	8.8	31,300,000	6.4	4.0
Totals	100.0	783,000,000	100.0	486,700,000	100.0	62.2

If it were desirable to increase the irrigation supply for the San Joaquin Valley from 334,000 acre-feet to 1,000,000 acre-feet per season, floods on the American River could be controlled to 100,000 second-feet at Fairoaks and the inflow into the delta could be maintained at 5000 second-feet for salinity control and to meet the irrigation demands of the delta as in the previous study, but the power value of the development would be materially impaired. A study has been made with these assumptions and the power output estimated for the period 1905–1927. Floods and salinity would have been controlled as anticipated and an irrigation supply of 1,000,000 acre-feet per season would have been made available for transportation to the San Joaquin Valley, with a deficiency in supply, however, of 32 per cent of a perfect seasonal supply in 1924. In order to furnish a perfect supply in a year like 1924, larger reservoir capacity would be required. The power output would have been seasonal in character and reduced to an average annual output of 585,700,000 kilowatt hours. The yearly power outputs are set forth in Table 67 and the power characteristics are given in Table 68.

TABLE 67. POWER OUTPUT OF COMPLETE CONSOLIDATED DEVELOPMENT OPERATED COORDINATELY FOR FLOOD CONTROL, SALINITY CONTROL, IRRIGATION AND POWER

Folsom reservoir—
- Height of dam, 190 feet.
- Capacity of reservoir, 355,000 acre-feet.
- Installed capacity of power plant, 54,000 k.v.a. P.F. =0.80.
- Maximum reservation for flood control, 175,000 acre-feet.
- Reservation for salinity control, 135,000 acre-feet.

Auburn reservoir—
- Height of dam, 390 feet.
- Capacity of reservoir, 598,000 acre-feet.
- Installed capacity of power plant, 66,000 k.v.a P.F. =0.80.
- Maximum reservation for flood control, 200,000 acre-feet.
- Reservation for salinity control, 242,000 acre-feet.

Coloma reservoir—
- Height of dam, 340 feet.
- Capacity of reservoir, 766,000 acre-feet.
- Installed capacity of power plant, 30,000 k.v.a P.F. =0.80.
- Maximum reservation for flood control, 125,000 acre-feet.
- Reservation for salinity control, 420,000 acre-feet.

Pilot Creek reservoir—
- Height of dam, 110 feet.
- Installed capacity of power plant, 19,000 k.v.a. P.F. =0.80.

Webber Creek reservoir—
- Height of dam, 90 feet.
- Installed capacity of power plant, 10,000 k.v.a. P.F. =0.80.

Floods controlled to 100,000 second-feet maximum flow at Fairoaks.
Inflow into the delta of the Sacramento and San Joaquin rivers maintained at 5,000 second-feet for salinity control and to meet the irrigation demands of the delta
Irrigation supply for San Joaquin Valley of 1,000,000 acre-feet per season (deficiency of 32 per cent of perfect seasonal supply in 1924) at maximum rate of 3,000 second-feet

Year	Power output in kilowatt hours Load factor = 0.75 No primary power
1905	641,200,000
1906	697,100,000
1907	739,700,000
1908	598,100,000
1909	795,100,000
1910	652,400,000
1911	654,400,000
1912	479,400,000
1913	440,200,000
1914	606,700,000
1915	586,000,000
1916	674,400,000
1917	615,500,000
1918	480,800,000
1919	483,700,000
1920	456,400,000
1921	631,800,000
1922	598,600,000
1923	659,800,000
1924	354,000,000
1925	463,200,000
1926	478,400,000
1927*	537,600,000
Average	585,700,000

*Partial year, January 1 to October 1.

TABLE 68. CHARACTERISTICS OF POWER OUTPUT OF COMPLETE CONSOLIDATED DEVELOPMENT OPERATED COORDINATELY FOR FLOOD CONTROL, SALINITY CONTROL, IRRIGATION AND POWER

1905-1927

Folsom reservoir—
- Height of dam, 190 feet.
- Capacity of reservoir, 355,000 acre-feet.
- Installed capacity of power plant, 54,000 k.v.a. P.F. =0 80.
- Maximum reservation for flood control, 175,000 acre-feet.
- Reservation for salinity control 135,000 acre-feet.

Auburn reservoir—
- Height of dam, 390 feet.
- Capacity of reservoir, 598,000 acre-feet
- Installed capacity of power plant, 66,000 k.v.a P.F. =0.80.
- Maximum reservation for flood control, 200,000 acre-feet.
- Reservation for salinity control, 242,000 acre-feet.

Coloma reservoir—
- Height of dam, 340 feet.
- Capacity of reservoir, 766,000 acre-feet.
- Installed capacity of power plant, 30,000 k.v.a P.F. =0.80.
- Maximum reservation for flood control, 125,000 acre-feet.
- Reservation for salinity control, 420,000 acre-feet.

Pilot Creek reservoir—
- Height of dam, 110 feet.
- Installed capacity of power plant, 19,000 k.v.a. P.F. =0.80.

Webber Creek reservoir—
- Height of dam, 90 feet.
- Installed capacity of power plant, 10,000 k.v.a. P.F. =0.80.

Floods controlled to 100,000 second-feet maximum flow at Fairoaks

Inflow into delta of the Sacramento and San Joaquin rivers maintained at 5,000 second-feet for salinity control and to meet the irrigation demands of the delta

Irrigation supply for San Joaquin Valley of 1,000,000 acre-feet per season (deficiency of 32 per cent of perfect seasonal supply in 1924) at maximum rate of 3,000 second-feet

Average annual power output, 585,700,000 kilowatt hours

Month	State-wide average monthly demand for power in per cent of annual total	Power output in kilowatt hours Load factor = 0.75				
		Maximum year, 1909		Minimum year, 1924		
		Kilowatt hours	Per cent of annual total	Kilowatt hours	Per cent of annual total	Per cent of annual total of maximum year
January	7.3	74,400,000	9.4	0	0	0
February	6.9	67,200,000	8.5	9,000,000	2.5	1.1
March	7.8	74,300,000	9.3	22,700,000	6.4	2.8
April	7.9	72,000,000	9.1	50,300,000	14.2	6.3
May	8.8	74,400,000	9.4	74,400,000	21.0	9.4
June	9.0	72,000,000	9.1	71,400,000	20.2	9.0
July	9.4	74,300,000	9.3	65,300,000	18.4	8.2
August	9.5	71,700,000	9.0	39,600,000	11.2	5.0
September	8.7	51,100,000	6.4	14,400,000	4.1	1.8
October	8.5	18,400,000	2.3	6,900,000	2.0	0.9
November	8.0	71,000,000	8.9	0	0	0
December	8.2	74,300,000	9.3	0	0	0
Totals	100.0	795,100,000	100.0	354,000,000	100.0	44.5

CHAPTER IX

COST OF CONSOLIDATED DEVELOPMENT

General.

Estimates of cost of the consolidated development have been prepared for the three stages of development both under State and private financing. These estimates include the cost of dams, flood control features in the major dams, power plants below the dams, all necessary lands and rights of way required for the consummation of the project, and removal of certain improvements from the flooded area, and compensation to owners of all property that would be destroyed within the reservoir area. The layouts at the dams are similar to those proposed by the American River Hydro-electric Company. The surveys of the American River Hydro-electric Company have been used as a basis for estimating the costs of the various features.

A gravity-concrete type of dam has been used in estimating the cost* of the dams for the several reservoirs. The non-overflow section has a crest width of 20 feet, a slope of $\frac{2}{3}$ to 1 on the downstream face and a slope of 1/20 to 1 on the upstream face. The section containing the flood control outlets is the non-overflow type but slightly heavier. Its crest width and slope on the upstream face are the same as for the non-overflow section without flood control outlets but the slope on the downstream face is increased to 4/5 to 1. The overflow spillway is an ogee section proportioned to receive the drum gates at its crest and the upper portion of its downstream face is shaped to fit the lower nappe line of the overflowing water. The auxiliary earth fill dikes of the Folsom reservoir have a crest width of 20 feet, a slope of 3 to 1 on the upstream face and a slope of $2\frac{1}{2}$ to 1 on the downstream face. A puddled core is provided along the center line of the dike and the upstream face is rip-rapped with rock, 12 inches in thickness.

Deep cut-off walls are provided at the upstream toe of all concrete sections. The foundation below the cut-off walls would be drilled and grouted. Drainage wells and collection galleries are provided downstream from the cut-off walls.

Excavation quantities for the dam foundations have been based on a reconnaissance of the sites, the findings of Hyde Forbes in his geological examination, and in the case of the Folsom dam site, also on logs of borings made by the American River Hydro-electric Company.

Folsom reservoir.

The general layout at the Folsom dam showing the relative location of the various features together with dam and tunnel sections used in the preparation of the estimates of cost are delineated on Plate VIII, "Folsom dam with power plant and flood control features." Curves of area and capacity of the Folsom reservoir are also shown on the plate.

The central and maximum section of the dam is the non-overflow gravity-concrete type. It rises 190 feet above low water to elevation 395 feet, and, as estimated, extends to bed rock 60 feet below low water.

* The estimated costs contained herein are preliminary. The costs of dams are based on a gravity-concrete section that is considered adaptable to good foundation conditions. Detailed exploratory work and further study might alter the type and section of dam finally selected for any particular site, resulting in a variation from these estimates.

Sluiceways are provided in this section of the dam for the purpose of unwatering and for supplementing the capacity of the power tunnel in meeting the maximum irrigation demand. The sluiceway installation consists of four outlets, each 66 inches in diameter, and is placed 140 feet below the crest of the dam. Each outlet is provided with a roller sluice gate which is protected by a trash rack structure at the upstream face of the dam. One of the battery of outlets has a balanced needle valve at the downstream end for regulating purposes. All outlets are lined with steel.

An overflow spillway located on the right abutment is incorporated in the dam. The depth of the spillway lip below the crest of the dam is 21 feet. Without flood control features included in the dam, its overall length is 1180 feet and has a capacity of 250,000 and 375,000 second-feet with a head on the spillway lip of 16 and 21 feet, respectively. With flood control features in the dam, as shown on Plate VIII, the overall length of the spillway is 470 feet and has a capacity of 100,000 second-feet with a head on the spillway lip of 16 feet. With a head of 21 feet it has a capacity of 150,000 second-feet. Flow over the spillway with flood control features in the dam is controlled by eight steel drum gates, 16 feet deep and 50 feet long, hydraulically operated. A spillway channel intercepts the flow over the spillway and discharges it into the stream channel 700 feet downstream from the dam. Lack of information as to characteristics of the underlying rock along the course of the spillway channel prevents an accurate estimate to be made of the treatment that should be followed. Exploration by drilling or other means alone can determine this. However, a sum of $200,000 without flood control features in the dam and $100,000 with flood control features, has been included in the estimates of cost for the preparation of the spillway channel.

The section of the dam containing the flood control features is located on the left abutment. These features consist of eighteen 14-foot by 14-foot openings through the dam, spaced 28 feet, capable of discharging 100,000 second-feet with the reservoir drawn down to elevation 355 feet. Flow through the outlets is controlled by roller sluice gates at the upstream face of the dam. Each gate is operated by an electric hoist at the top of the dam. A trash rack structure at the upstream face of the dam with provision for stop logs protects and assures operation of the sluice gates. A natural channel exists below the flood control outlets, which, if improved, would be capable of conveying the water released through the outlets to the stream channel 700 feet downstream from the dam. As in the case of the channel for the overflow spillway, lack of data as to the foundation conditions does not permit of an accurate estimate to be made of cost of the channel. A sum of $100,000 has been allowed in the cost estimates for this purpose.

A low earth dike would extend from the end of the gravity-concrete section on the right abutment to the North Fork reservoir, a distance of 1700 feet.

The power plant is located on the left bank of the river. An intake structure of reinforced concrete with control gates, 400 feet upstream from the dam, controls the flow into the penstock tunnel leading to the power house. The tunnel section, shown on Plate VIII, is lined with concrete, 12 inches thick and reinforced with steel where the overburden

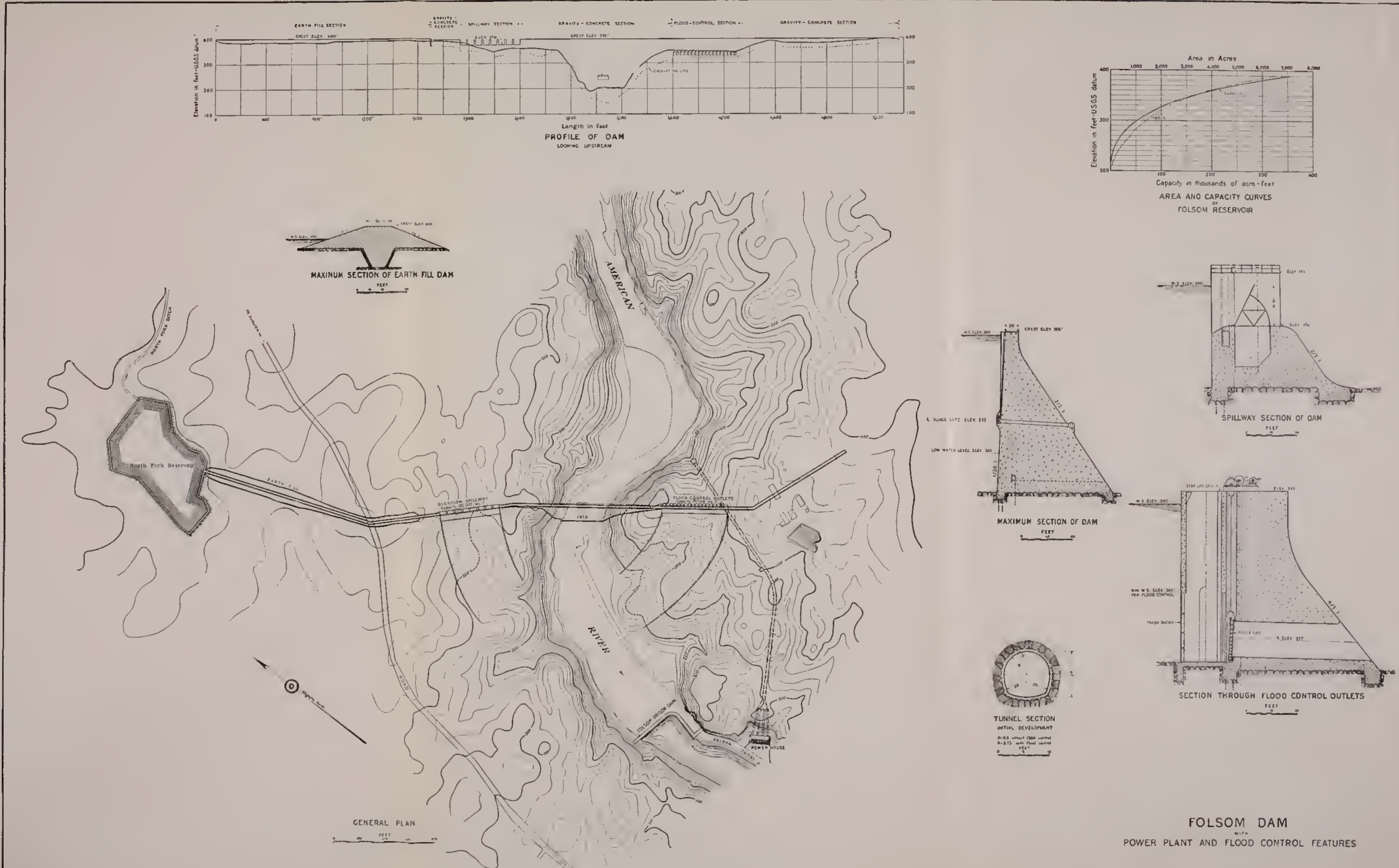
Sluiceways are provided in this section of the dam for the purpose of unwatering and for supplementing the capacity of the power tunnel in meeting the maximum irrigation demand. The sluiceway installation consists of four outlets, each 66 inches in diameter, and is placed 140 feet below the crest of the dam. Each outlet is provided with a roller sluice gate which is protected by a trash rack structure at the upstream face of the dam. One of the battery of outlets has a balanced needle valve at the downstream end for regulating purposes. All outlets are lined with steel.

An overflow spillway located on the right abutment is incorporated in the dam. The depth of the spillway lip below the crest of the dam is 21 feet. Without flood control features included in the dam, its overall length is 1180 feet and has a capacity of 250,000 and 375,000 second-feet with a head on the spillway lip of 16 and 21 feet, respectively. With flood control features in the dam, as shown on Plate VIII, the overall length of the spillway is 470 feet and has a capacity of 100,000 second-feet with a head on the spillway lip of 16 feet. With a head of 21 feet it has a capacity of 150,000 second-feet. Flow over the spillway with flood control features in the dam is controlled by eight steel drum gates, 16 feet deep and 50 feet long, hydraulically operated. A spillway channel intercepts the flow over the spillway and discharges it into the stream channel 700 feet downstream from the dam. Lack of information as to characteristics of the underlying rock along the course of the spillway channel prevents an accurate estimate to be made of the treatment that should be followed. Exploration by drilling or other means alone can determine this. However, a sum of $200,000 without flood control features in the dam and $100,000 with flood control features, has been included in the estimates of cost for the preparation of the spillway channel.

The section of the dam containing the flood control features is located on the left abutment. These features consist of eighteen 14-foot by 14-foot openings through the dam, spaced 28 feet, capable of discharging 100,000 second-feet with the reservoir drawn down to elevation 355 feet. Flow through the outlets is controlled by roller sluice gates at the upstream face of the dam. Each gate is operated by an electric hoist at the top of the dam. A trash rack structure at the upstream face of the dam with provision for stop logs protects and assures operation of the sluice gates. A natural channel exists below the flood control outlets, which, if improved, would be capable of conveying the water released through the outlets to the stream channel 700 feet downstream from the dam. As in the case of the channel for the overflow spillway, lack of data as to the foundation conditions does not permit of an accurate estimate to be made of cost of the channel. A sum of $100,000 has been allowed in the cost estimates for this purpose.

A low earth dike would extend from the end of the gravity-concrete section on the right abutment to the North Fork reservoir, a distance of 1700 feet.

The power plant is located on the left bank of the river. An intake structure of reinforced concrete with control gates, 400 feet upstream from the dam, controls the flow into the penstock tunnel leading to the power house. The tunnel section, shown on Plate VIII, is lined with concrete, 12 inches thick and reinforced with steel where the overburden



FOLSOM DAM
WITH
POWER PLANT AND FLOOD CONTROL FEATURES

is not of sufficient depth. If the Folsom reservoir were constructed as a single unit, the diameter of the tunnel would be 16.0 feet without and 17.0 feet with flood control features included in the dam. If it were constructed in conjunction with Auburn and Coloma reservoirs, the diameter would be 18.0 and 19.7 feet without and with flood control features, respectively. Four steel penstocks connect the tunnel to four vertical variable head reaction turbines directly connected to generators. Water from the turbines would be either all discharged into the Folsom Canal or part into the canal and part into the stream below, according to the plant layout. The plans of the American River Hydro-electric Company contemplate the latter layout while those proposed in this report would discharge the entire flow from the turbines into the Folsom Canal, deepened 7 feet for about 1600 feet at its upper end.

Estimates of cost of the Folsom reservoir have been prepared both with and without flood control features, under both state and private financing and for various power plant installations. The power plant installations vary with the stage of the development, plant load factor and plant layout at the dam. For the plant layout with all the tail-water discharged into the Folsom Canal at elevation 200 feet, and for a plant load factor of 0.75, the installations are 43,000 k.v.a and 54,000 k.v.a. for the initial and second stage of development, respectively. For the plant layout with tail-water discharged partly into the Folsom Canal at elevation 207 feet and partly into the American River below the Folsom Canal at elevation 162 feet, the plan of the American River Hydro-electric Company, and for a plant load factor of 1.00, the installations are 35,000 k.v.a. and 45,000 k.v.a. for the initial and second stage of development, respectively. The installations for the complete development are the same as for the second stage of development for corresponding plant layouts.

In Table 69 is set forth the cost of the Folsom reservoir as the initial development without flood control features, and with interest during construction at both 4½ and 6 per cent per annum, State and private financing, respectively. The power plant installation is 43,000 k.v.a.

Table 70 sets forth similar costs with flood control features included. These estimates together with those for the other power plant layouts and installations are summarized in Table 77.

TABLE 69. ESTIMATED COST OF FOLSOM RESERVOIR AND POWER PLANT WITHOUT FLOOD CONTROL FEATURES

Auburn and Coloma reservoirs not constructed

Height of dam, 190 feet — Capacity of reservoir, 355,000 acre-feet

Capacity of overflow spillway, 250,000 second-feet

Tailrace elevation of power plant, 200 feet

Installed capacity of power plant, 43,000 k. v. a. P. F. = 0.80 L. F. = 0.75

Interest during construction at 4½ per cent

DAM AND RESERVOIR—		
Exploration and core drilling	$20,000	$20,000
Diversion of river during construction	75,000	75,000
Clearing reservoir site, 6,460 acres at $25.00	162,000	162,000
Excavation for dam and spillway, 370,000 cu. yds. at $1.00 to $10.00	627,000	
Mass concrete, 498,000 cu. yds. at $6.30	3,137,[illegible]00	
Reinforced concrete, 5,000 cu. yds. at $15.00 to $18.50	82,000	
Spillway gates, 4,000,000 lbs. at $0.10	400,000	
Spillway channel	200,000	
Sluiceways	50,000	
Drilling and grouting foundation	80,000	
Earth fill section of main dam	50,000	
Auxiliary dams	50,000	4,676,000
Lands and improvements flooded	1,086,000	1,086,000
Miscellaneous:		
Construction and permanent camps	180,000	
Construction railroad	115,000	295,000
Subtotal, dam and reservoir		$6,314,000
Administration and engineering at 10%		631,000
Contingencies at 15%		947,000
Interest during construction		437,000
Total cost of dam and reservoir		$8,329,000
POWER PLANT—		
Intake structure	$54,000	$54,000
Penstock:		
Tunnel excavation, 25,800 cu. yds. at $7.50 to $10.00	206,000	
Tunnel timbering	45,000	
Concrete tunnel lining, 8,500 cu. yds. at $20.00	170,000	
Reinforcing steel, 500,000 lbs. at $0.055	28,000	
Steel pipe, 686,000 lbs. at $0.085	58,000	507,000
Buildings and equipment, 43,000 k.v.a. at $35.00	1,505,000	1,505,000
Tailrace structure	65,000	65,000
Subtotal, power plant		$2,131,000
Administration and engineering at 10%		213,000
Contingencies at 15%		320,000
Interest during construction		133,000
Total cost of power plant		$2,797,000
Grand total cost of dam, reservoir and power plant		**$11,126,000**

Interest during construction at 6 per cent

Total cost of dam and reservoir	$8,478,000
Total cost of power plant	2,842,000
Grand total cost of dam, reservoir and power plant	**$11,320,000**

TABLE 70. ESTIMATED COST OF FOLSOM RESERVOIR AND POWER PLANT WITH FLOOD CONTROL FEATURES

Auburn and Coloma Reservoirs not constructed

Height of dam, 190 feet — Capacity of reservoir, 355,000 acre-feet

Capacity of overflow spillway, 100,000 second-feet

Capacity of flood control outlets, 100,000 second-feet

Tailrace elevation of power plant, 200 feet

Installed capacity of power plant, 43,000 k. v. a. P. F. = 0.80 L. F. = 0.75

Interest during construction at 4½ per cent

DAM and RESERVOIR—		
Exploration and core drilling	$20,000	$20,000
Diversion of river during construction	75,000	75,000
Clearing of reservoir site, 6,460 acres at $25.00	162,000	162,000
Excavation for dam and spillway, 390,000 cu. yds. at $1.00 to $10.00	682,000	
Mass concrete, 510,000 cu. yds. at $6.30	3,213,000	
Reinforced concrete, 3,000 cu. yds. at $15.00 to $23.50	55,000	
Spillway gates, 1,600,000 lbs. at $0.10	160,000	
Spillway channel	100,000	
Sluiceways	50,000	
Drilling and grouting foundation	80,000	
Earth fill section of main dam	50,000	
Auxiliary dams	50,000	4,440,000
Lands and improvements flooded	1,086,000	1,086,000
Miscellaneous:		
Construction and permanent camps	180,000	
Construction railroads	115,000	295,000
Subtotal, dam and reservoir		$6,078,000
Administration and engineering at 10%		608,000
Contingencies at 15%		912,000
Interest during construction		431,000
Total cost of dam and reservoir		$8,029,000
FLOOD CONTROL FEATURES—		
Excavation, 60,000 cu. yds. at $1.50	$90,000	$90,000
Trash racks	50,000	50,000
Reinforced concrete, 7,700 cu. yds. at $25.00	192,000	192,000
Gates, 18-14'x14' sluice gates with hoists	165,000	165,000
Flood control channel	100,000	100,000
Subtotal, flood control features		$597,000
Administration and engineering at 10%		60,000
Contingencies at 15%		90,000
Interest during construction		25,000
Total cost of flood control features		$772,000
POWER PLANT—		
Intake structure	$60,000	$60,000
Penstock:		
Tunnel excavation, 30,500 cu. yds. at $7.00 to $9.00	225,000	
Tunnel timbering	50,000	
Concrete tunnel lining, 9,300 cu. yds. at $20.00	186,000	
Reinforcing steel, 550,000 lbs. at $0.055	30,000	
Steel pipe, 862,000 lbs. at $0.085	73,000	564,000
Building and equipment, 43,000 k.v.a. at $35.00	1,505,000	1,505,000
Tailrace structure	65,000	65,000
Subtotal, power plant		$2,194,000
Administration and engineering at 10%		220,000
Contingencies at 15%		329,000
Interest during construction		139,000
Total cost of power plant		$2,882,000
Grand total cost of dam, reservoir, flood control features and power plant		**$11,684,000**

Interest during construction at 6 per cent

Total cost of dam and reservoir	$8,178,000
Total cost of flood control features	780,000
Total cost of power plant	2,930,000
Grand total cost of dam, reservoir, flood control features and power plant	**$11,888,000**

Auburn reservoir.

On Plate IX, "Auburn dam with power plan and flood control features," are shown the dam and the arrangement of its several features. Sections of the dam together with area and capacity curves of the Auburn reservoir are also shown on the plate. With the exception of the portions occupied by the overflow spillway and the flood control features, the dam section is the non-overflow gravity-concrete type. The maximum section has a height of 390 feet above low water and it is estimated that 15 feet of stripping would be required to obtain a suitable foundation. The length on the crest at elevation 905 feet is 1600 feet.

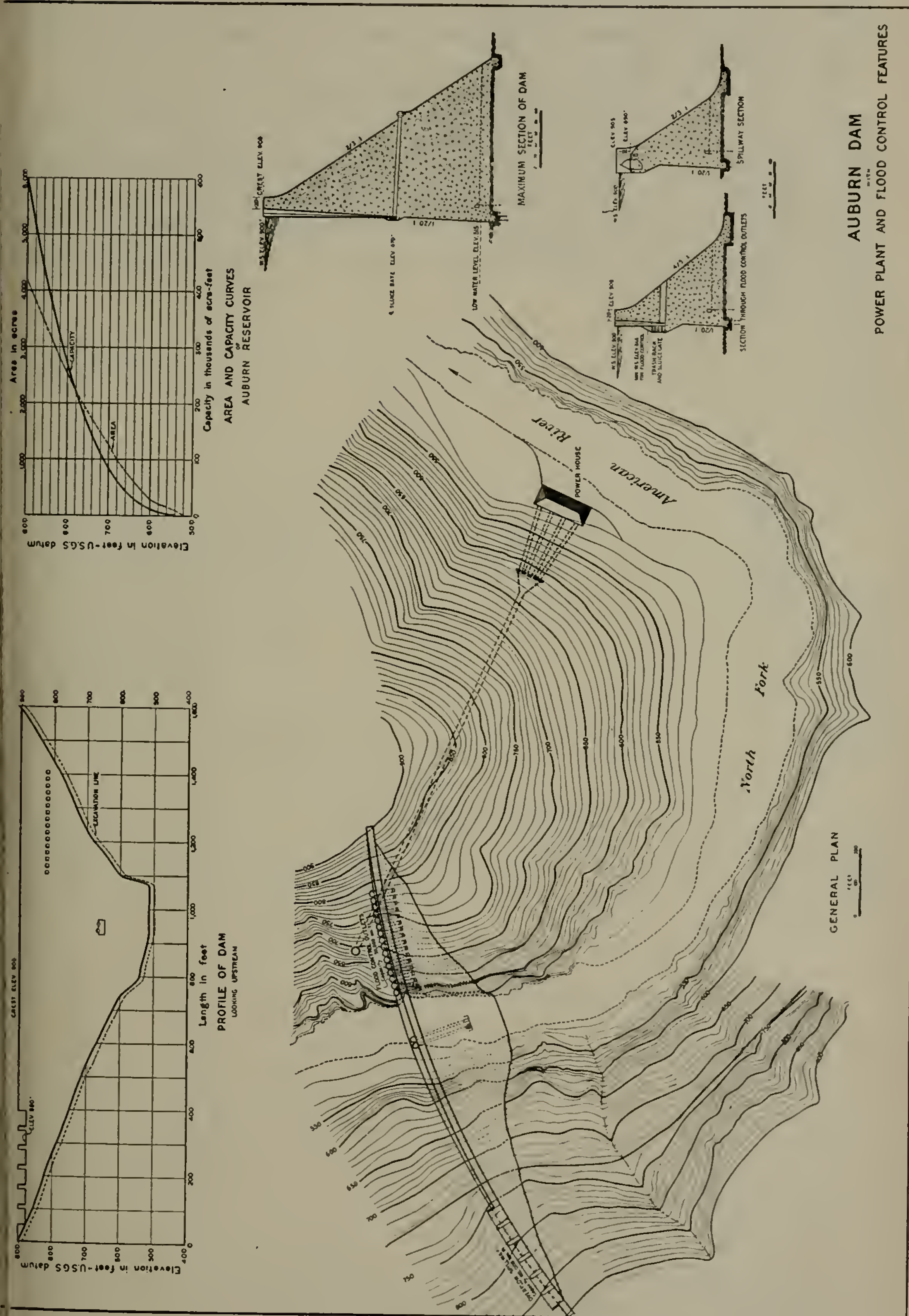
The overflow spillway, located on the right abutment, has an overall length of 360 feet if flood control features are included in the dam. Its capacity, with a depth of 20 feet on the spillway lip, is 100,000 second-feet and with the water level at the crest of the dam, is 144,000 second-feet. If flood control features were not included in the dam, the capacity of the spillway would be larger. In this instance the overall length would be 608 feet, with a net length of 500 feet and with a depth of 20 feet on the spillway lip, its capacity would be 170,000 second-feet. As shown on Plate IX, with flood control features, flow over the spillway is controlled by six steel drum gates, each 50 feet long and 20 feet deep, hydraulically operated. It is believed that the character of the rock at the site would not necessitate the construction of a definite spillway channel for the purpose of conveying the water discharged over the spillway into the stream below the dam.

The flood control features in the Auburn dam are similar to those in the Folsom dam. Sixteen 10-foot by 10-foot outlets are provided and are located on the left abutment. The outlets 77 feet below the top of the dam have a capacity of 50,000 second-feet, with the reservoir drawn down to the minimum flood control level at elevation 846 feet. Roller sluice gates and a trash rack structure are provided at the upstream face of the dam.

Two sluiceways are provided in the central portion of the dam for the purpose of unwatering the power tunnel and also to supplement the capacity of the power tunnel in passing the maximum irrigation draft if the reservoir were operated primarily for irrigation purposes. Each sluiceway has a diameter of 62 inches and is lined with steel. The total capacity of the sluiceways is 1500 second-feet with the reservoir drawn to one-half depth. Control of flow is obtained by means of roller sluice gates at the upstream face and a balanced needle valve on one outlet at the downstream face. Trash racks around the sluice gates are provided at the upstream face of the dam.

The power house is located on the left bank about 2400 feet downstream from the dam. Water would be delivered to the turbines through a tunnel controlled by means of roller sluice gates in a reinforced concrete intake structure about 100 feet upstream from the dam. The power tunnel is about 1250 feet long and is lined with concrete, 12 inches thick, and reinforced with steel where the overburden is not sufficient to withstand the water pressure. Its diameter is 13.5 feet without reservoir operation for flood control purposes and 14.5 feet with flood control. About 200 feet above the power house, the tunnel divides into 4 steel penstocks which would deliver the water to four

PLATE IX



AUBURN DAM WITH POWER PLANT AND FLOOD CONTROL FEATURES vertical variable head reaction turbines, directly connected to generators. The installed capacity of the power plant is 66,000 k.v.a. for a plant load factor of 0.75 as proposed in this report and 82,000 k.v.a. for a plant load factor of 0.60, as proposed by the American River Hydro-electric Company.

The cost of the Auburn reservoir without flood control features and with interest during construction at $4\frac{1}{2}$ and 6 per cent, State and private financing, respectively, is set forth in Table 71.

Table 72 gives similar information with flood control features included. The power plant installation in each instance is 66,000 k.v.a., with a plant load factor of 0.75. These estimates together with those with a power plant installation of 82,000 k.v.a. are summarized in Table 77.

TABLE 71. ESTIMATED COST OF AUBURN RESERVOIR AND POWER PLANT WITHOUT FLOOD CONTROL FEATURES

Height of dam, 390 feet — Capacity of reservoir, 598,000 acre-feet

Capacity of overflow spillway, 170,000 second-feet

Installed capacity of power plant, 66,000 k.v.a. P.F. = 0.80 L.F. = 0.75

Interest during construction at 4½ per cent

Dam and Reservoir—		
Exploration and core drilling	$20,000	$20,000
Diversion of river during construction	50,000	50,000
Clearing reservoir site, 4,200 acres at $60.00	252,000	252,000
Excavation for dam, 140,000 cu. yds. at $2.50 to $5.00	455,000	
Mass concrete, 1,153,000 cu. yds. at $6.50	7,495,000	
Reinforced concrete, 7,000 cu. yds. at $15.00 to $23.00	112,000	
Spillway gates, 3,000,000 lbs. at $0.10	300,000	
Sluiceways	50,000	
Drilling and grouting foundation	36,000	8,448,000
Lands and improvements flooded	855,000	855,000
Construction and permanent camps	250,000	250,000
Subtotal, dam and reservoir		$9,875,000
Administration and engineering at 10%		988,000
Contingencies at 15%		1,481,000
Interest during construction		781,000
Total cost of dam and reservoir		$13,125,000
Power Plant—		
Intake structure	$93,000	$93,000
Penstock:		
Tunnel excavation, 13,400 cu. yds. at $9.00 to $10.50	127,000	
Tunnel timbering	25,000	
Concrete tunnel lining, 5,180 cu. yds. at $20.00	104,000	
Reinforcing steel, 470,000 lbs. at $0.055	26,000	
Steel pipe, 1,000,000 lbs. at $0.085	85,000	
Reinforced concrete	10,000	377,000
Buildings and equipment, 66,000 k.v.a. at $35.00	2,310,000	2,310,000
Subtotal, power plant		$2,780,000
Administration and engineering at 10%		278,000
Contingencies at 15%		417,000
Interest during construction		158,000
Total cost of power plant		$3,633,000
Grand total cost of reservoir, dam and power plant		**$16,758,000**

Interest during construction at 6 per cent

Total cost of dam and reservoir	$13,396,000
Total cost of power plant	3,686,000
Grand total cost of dam, reservoir and power plant	**$17,082,000**

TABLE 72. ESTIMATED COST OF AUBURN RESERVOIR AND POWER PLANT WITH FLOOD CONTROL FEATURES

Height of dam, 390 feet Capacity of reservoir, 598,000 acre-feet

Capacity of overflow spillway, 100,000 second-feet

Capacity of flood control outlets, 50,000 second-feet

Installed capacity of power plant, 66,000 k. v. a. P. F. = 0.80 L. F. = 0.75

Interest during construction at 4½ per cent

DAM AND RESERVOIR—		
Exploration and core drilling	$20,000	$20,000
Diversion of river during construction	50,000	50,000
Clearing reservoir site, 4,200 acres at $60.00	252,000	252,000
Excavation for dam, 144,000 cu. yds. at $2.50 to $5.00	470,000	
Mass concrete, 1,178,000 cu. yds. at $6.50	7,657,000	
Reinforced concrete, 5,300 cu. yds. at $15.00 to $23.00	86,000	
Spillway gates, 1,800,000 lbs. at $0.10	180,000	
Sluiceways	50,000	
Drilling and grouting foundation	36,000	8,479,000
Lands and improvements flooded	855,000	855,000
Construction and permanent camps	250,000	250,000
Subtotal, dam and reservoir		$9,906,000
Administration and engineering at 10%		991,000
Contingencies at 15%		1,486,000
Interest during construction		791,000
Total cost of dam and reservoir		$13,174,000
FLOOD CONTROL FEATURES—		
Trash racks	$35,000	$35,000
Reinforced concrete, 8,000 cu. yds. at $15.00 to $25.00	138,000	138,000
Gates, 16—10'x10' sluice gates with hoists	110,000	110,000
Subtotal, flood control features		$283,000
Administration and engineering at 10%		28,000
Contingencies at 15%		43,000
Interest during construction		12,000
Total cost of flood control features		$366,000
POWER PLANT—		
Intake structure	$96,000	$96,000
Penstock:		
Tunnel excavation, 14,900 cu. yds. at $8.00 to $10.00	128,000	
Tunnel timbering	27,000	
Concrete tunnel lining, 5,400 cu. yds. at $20.00	108,000	
Reinforcing steel, 520,000 lbs. at $0.055	29,000	
Steel pipe, 1,120,000 lbs. at $0.085	95,000	
Reinforced concrete	10,000	397,000
Buildings and equipment, 66,000 k.v.a. at $35.00		2,310,000
Subtotal, power plant		$2,803,000
Administration and engineering at 10%		280,000
Contingencies at 15%		421,000
Interest during construction		161,000
Total cost of power plant		$3,665,000
Grand total cost of dam, reservoir, flood control features and power plant		**$17,205,000**

Interest during construction at 6 per cent

Total cost of dam and reservoir	$13,447,000
Total cost of flood control features	370,000
Total cost of power plant	3,719,000
Grand total cost of dam, reservoir, flood control features and power plant	**$17,536,000**

Pilot Creek reservoir.

The arrangement of the works at the Pilot Creek dam is shown on Plate X, "Pilot Creek dam with power plant." The dam is an overflow type gravity-concrete dam, 110 feet high measured above low water and with a crest length of 500 feet. The depth of stripping is estimated at 15 feet. The dam with a depth on crest of 20 feet would pass 175,000 second-feet. There are no crest gates or sluiceways. Provision is made for passing 60 second-feet of prior right water of the North Fork ditch through the right abutment of the dam. The power plant is located on the left bank, about 500 feet downstream from the dam. The power tunnel is 13.5 feet in diameter, the same size as the tunnel for the Auburn reservoir without flood control features and has a capacity of 1500 second-feet. It is lined with concrete. Control is effected by two sluice gates near upper end of the tunnel. At the lower end, the tunnel divides into four steel penstocks which connect to constant head turbines of the four generating units. These units have an aggregate capacity of 19,000 k.v.a. for a plant load factor of 0.75 and 23,000 k.v.a. for a plant load factor of 0.60. The estimated cost of the reservoir with a power plant capacity of 19,000 k.v.a. is set forth in Table 73, with interest during construction at 4½ and 6 per cent, State and private financing, respectively. This estimate and one with a power plant capacity of 23,000 k.v.a. are summarized in Table 77.

PLATE X

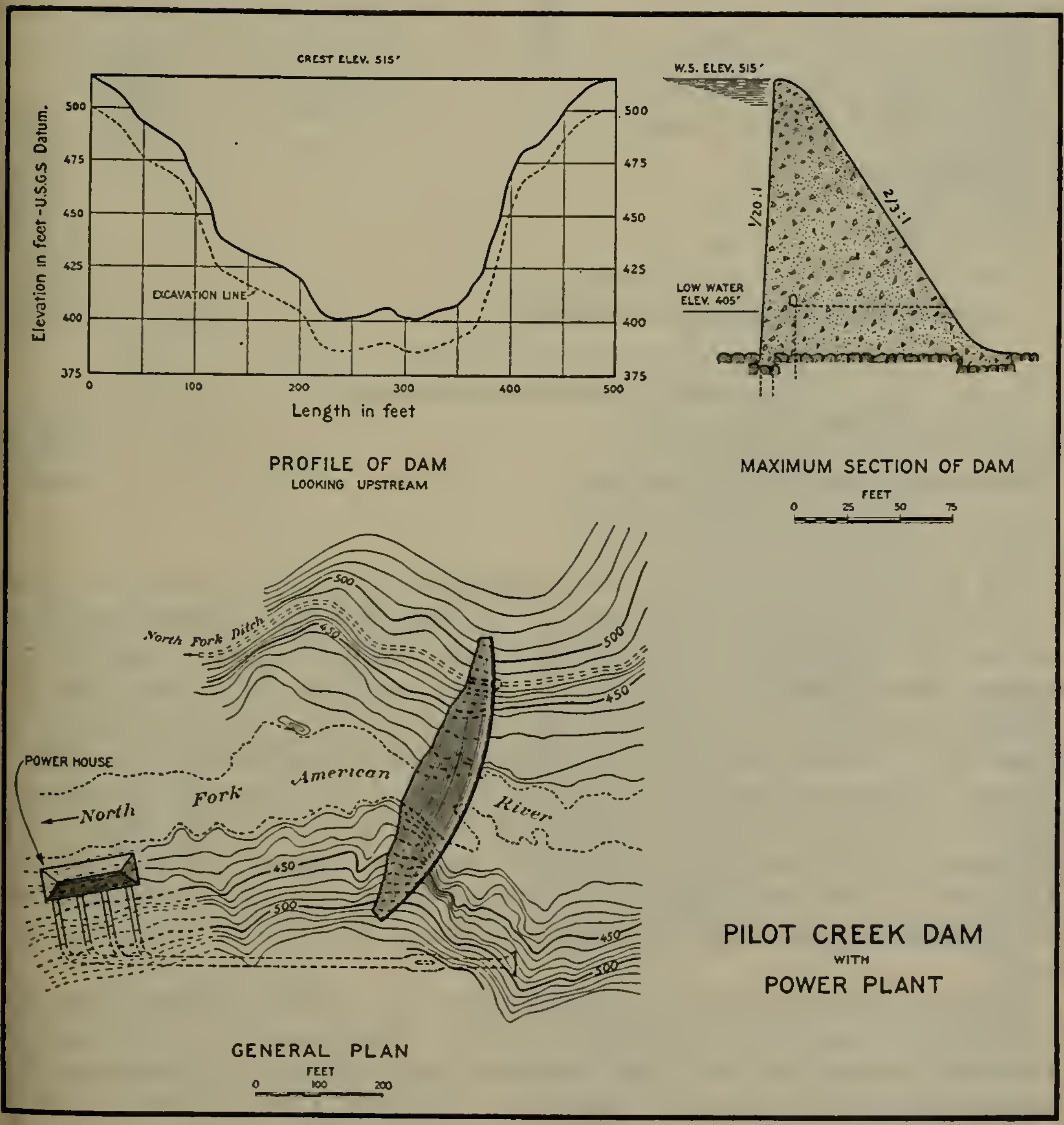


TABLE 73. ESTIMATED COST OF PILOT CREEK RESERVOIR AND POWER PLANT

Height of dam, 110 feet — Overflow dam

Installed capacity of power plant, 19,000 k. v. a. P. F. = 0.80 L. F. = 0.75

Interest during construction at 4½ per cent

DAM AND RESERVOIR—		
Exploration and core drilling	$10,000	$10,000
Diversion of river during construction	50,000	50,000
Clearing of reservoir site, 260 acres at $60.00	16,000	16,000
Excavation for dam, 20,000 cu. yds. at $3.00 to $5.00	70,000	
Mass concrete, 62,000 cu. yds. at $6.50	403,000	
Drilling and grouting foundation	12,000	485,000
Lands and improvements flooded	25,000	25,000
Miscellaneous:		
Construction and permanent camps	80,000	
Construction railroad	60,000	140,000
Subtotal, dam and reservoir		$726,000
Administration and engineering at 10%		73,000
Contingencies at 15%		109,000
Interest during construction		31,000
Total cost dam and reservoir		$939,000
POWER PLANT—		
Intake structure	$30,000	$30,000
Penstocks:		
Tunnel excavation, 2,200 cu. yds. at $9.00	$20,000	
Tunnel timbering	4,000	
Concrete tunnel lining, 800 cu. yds. at $20.00	16,000	
Steel pipes, 380,000 lbs. at $0.15	57,000	97,000
Buildings and equipment, 19,000 k.v.a. at $35.00	665,000	665,000
Subtotal, power plant		$792,000
Administration and engineering at 10%		79,000
Contingencies at 15%		119,000
Interest during construction		34,000
Total cost of power plant		$1,024,000
Grand total cost of dam, reservoir and power plant		**$1,963,000**

Interest during construction at 6 per cent

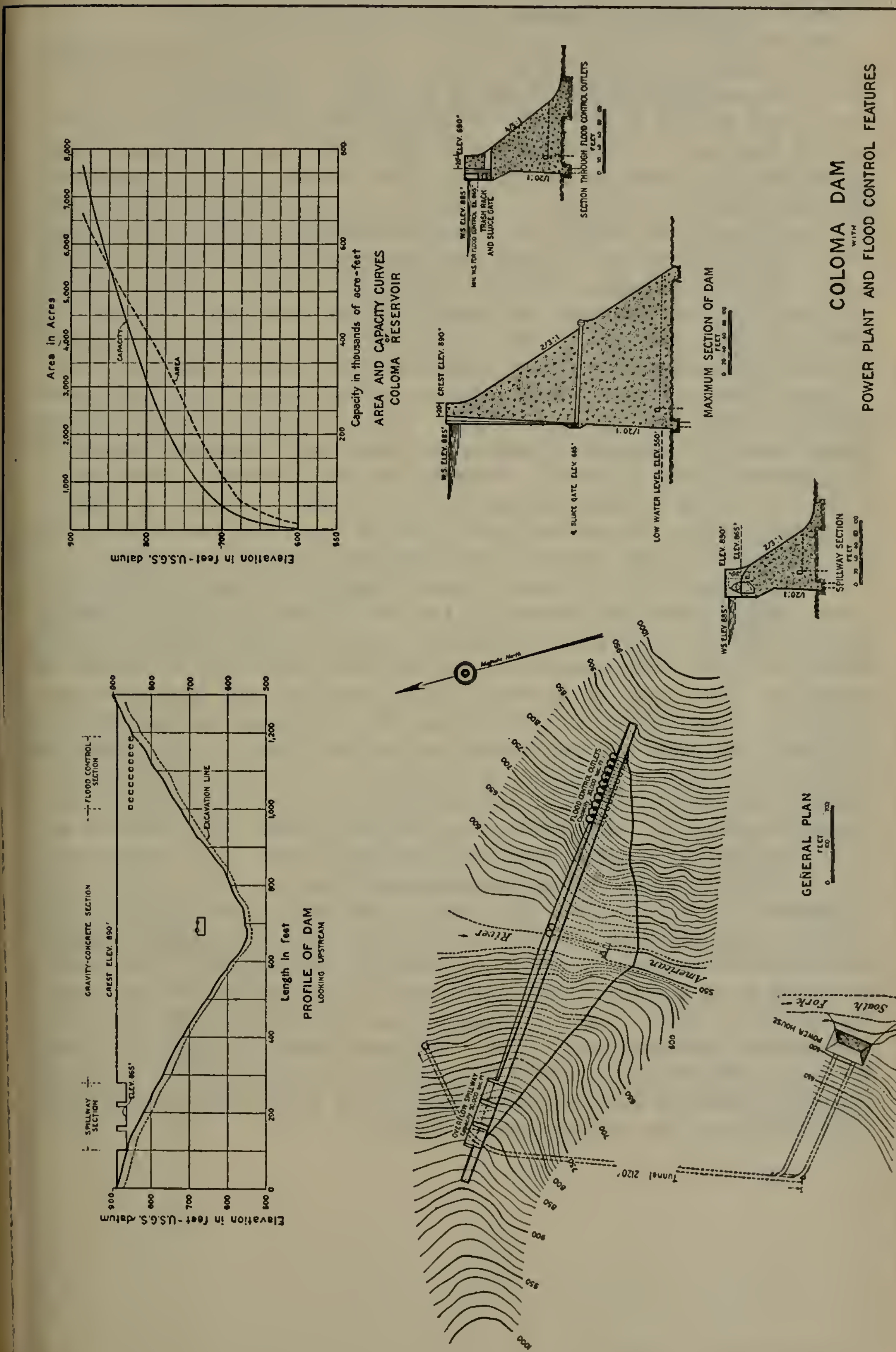
Total cost of dam and reservoir	$949,000
Total cost of power plant	1,035,000
Grand total cost of dam, reservoir and power plant	**$1,984,000**

Coloma reservoir.

The layout at the Coloma dam is similar to that at Auburn. The flood control features are located on the left and the overflow spillway on the right abutment. The power plant is on the right bank of the stream, about 2000 feet downstream from the dam. The arrangement of the various features together with sections of the dam are shown on Plate XI "Coloma dam with power plant and flood control features." Curves of area and capacity of the Coloma reservoir are also shown on Plate XI. Estimates of cost are based on a gravity-concrete dam. The maximum height would be 340 feet above low water. The depth of stripping for the foundation is estimated at 12 feet in the stream bed, 15 to 20 feet on the right abutment and from 20 to 25 on the left abutment.

The flood control features consist of ten 10-foot by 10-foot openings through the dam, 48 feet below the crest. The capacity of the outlets is 30,000 second-feet with the reservoir drawn down to elevation 865 feet, 25 feet below the top of the dam. Like the Auburn dam, the flow through each outlet is controlled by a roller sluice gate at the upstream

PLATE XI


Area in Acres
Capacity in thousands of acre-feet
Elevation in feet-U.S.G.S. datum
CAPACITY
AREA
AREA AND CAPACITY CURVES OF COLOMA RESERVOIR
SECTION THROUGH FLOOD CONTROL OUTLETS
CREST ELEV. 890'
MAXIMUM SECTION OF DAM
SPILLWAY SECTION
GRAVITY-CONCRETE SECTION
CREST ELEV. 890'
SPILLWAY SECTION
FLOOD CONTROL SECTION
EXCAVATION LINE
Length in feet
PROFILE OF DAM
LOOKING UPSTREAM
Magnetic North
FLOOD CONTROL OUTLETS
OVERFLOW SPILLWAY
American River
South Fork
POWER HOUSE
Tunnel 2120'
GENERAL PLAN
COLOMA DAM
WITH
POWER PLANT AND FLOOD CONTROL FEATURES

face of the dam operated by an electric hoist. A trash rack structure is provided around the gates.

The overflow spillway has an overall length of 174 feet with flood control features included in the dam. Without flood control features, the corresponding length would be 283 feet. The spillway lip is 25 feet below the top of the dam. The capacity of the spillway, if flood control features were included in the dam, would be 50,000 and 70,000 second-feet for a head on the spillway lip of 20 and 25 feet, respectively. Without flood control features in the dam, the capacity for corresponding heads would be 80,000 and 110,000 second-feet. Three steel drum gates, 20 feet deep and 50 feet long are provided for the control of water over the spillway, with flood control features in the dam. Without flood control features, five gates 20 feet deep and 47 feet long would be required. As in the case of the Auburn dam, no separate channel is provided either for overflow spillway or flood control outlets.

Two sluiceways, with a total capacity of 1800 second-feet, are placed 205 feet below the top of the dam. These together with the power tunnel would be capable of passing the maximum irrigation demand if the reservoir were operated primarily for that purpose. Each sluiceway is 66 inches in diameter and lined with steel. Control is effected by a roller sluice gate on each outlet at the upstream face of the dam and a balanced needle valve at the downstream end of one outlet.

The arrangement of the power plant is similar to that at the Auburn dam. Water would be conveyed to the power house in a power tunnel, 2120 feet long and 10 feet in diameter, which divides above the power house into two steel penstocks, each 350 feet long and 86 inches in diameter. The sizes of the tunnel and penstocks are the same both with and without flood control because the draw-down in the reservoir especially for flood control would be relatively small. The tunnel is lined with concrete, 12 inches in thickness. Control of flow into the tunnel is effected by roller sluice gates located in a reinforced concrete intake structure at the upstream end of the tunnel. The turbines are of the variable head reaction type directly connected to the generators. The installed capacity of the plant is 30,000 k.v.a. with a plant load factor of 0.75 and 37,000 k.v.a. with a plant load factor of 0.60.

The estimated cost of the Coloma reservoir and power plant without flood control features is given in Table 74, for interest during construction at 4½ and 6 per cent per annum, State and private financing, respectively. Table 75 gives corresponding information with flood control features included in the dam. The power plant installation in each instance is 30,000 k.v.a., based on a plant load factor of 0.75. These estimates together with estimates based on a power plant installation of 37,000 k.v.a. are summarized in Table 77.

TABLE 74. ESTIMATED COST OF COLOMA RESERVOIR AND POWER PLANT WITHOUT FLOOD CONTROL FEATURES

Height of dam, 340 feet — Capacity of reservoir, 766,000 acre-feet

Capacity of overflow spillway, 80,000 second-feet

Installed capacity of power plant, 30,000 k. v. a. P. F. = 0.80 L. F. = 0.75

Interest during construction at 4½ per cent

Dam and Reservoir—		
Exploration and core drilling	$20,000	$20,000
Diversion of river during construction	50,000	50,000
Clearing reservoir site, 6,565 acres at $25.00	164,000	164,000
Excavation for dam, 111,000 cu. yds. at $2.50 to $5.00	324,000	
Mass concrete, 724,000 cu. yds. at $7.00	5,068,000	
Reinforced concrete, 3,000 cu. yds. at $15.50 to $23.50	51,000	
Spillway gates, 1,420,000 lbs. at $0.10	142,000	
Sluiceways	50,000	
Drilling and grouting foundation	30,000	5,665,000
Lands and improvements flooded	1,500,000	1,500,000
Miscellaneous:		
Construction railroad	270,000	
Construction and permanent camps	200,000	470,000
Subtotal, dam and reservoir		$7,869,000
Administration and engineering at 10%		787,000
Contingencies at 15%		1,180,000
Interest during construction		710,000
Total cost of dam and reservoir		$10,546,000
Power Plant—		
Intake structure	$68,000	$68,000
Penstock:		
Tunnel excavation, 10,800 cu. yds. at $11.00 to $13.50	122,000	
Tunnel timbering	22,000	
Concrete tunnel lining, 5,150 cu. yds. at $20.00	103,000	
Reinforcing steel, 100,000 lbs. at $0.055	6,000	
Steel pipes, 825,000 lbs. at $0.085	70,000	
Reinforced concrete	5,000	328,000
Buildings and equipment, 30,000 k.v.a. at $35.00	1,050,000	1,050,000
Subtotal, power plant		$1,514,000
Administration and engineering at 10%		152,000
Contingencies at 15%		227,000
Interest during construction		105,000
Total cost of power plant		$1,998,000
Grand total cost dam, reservoir and power plant		**$12,544,000**

Interest during construction at 6 per cent

Total cost of dam and reservoir	$10,793,000
Total cost of power plant	2,035,000
Grand total cost dam, reservoir and power plant	**$12,828,000**

TABLE 75. ESTIMATED COST OF COLOMA RESERVOIR AND POWER PLANT WITH FLOOD CONTROL FEATURES

Height of dam, 340 feet — Capacity of reservoir, 766,000 acre-feet
Capacity of overflow spillway, 50,000 second-feet
Capacity of flood control outlets, 30,000 second-feet
Installed capacity of power plant, 30,000 k. v. a. P. F. = 0.80 L. F. = 0.75

Interest during construction at 4½ per cent

DAM AND RESERVOIR—		
Exploration and core drilling	$20,000	$20,000
Diversion of river during construction	50,000	50,000
Clearing reservoir site, 6,565 acres at $25.00	164,000	164,000
Excavation for dam, 113,000 cu. yds. at $2.50 to $5.00	351,000	
Mass concrete, 736,000 cu. yds. at $7.00	5,152,000	
Reinforced concrete, 2,500 cu. yds. at $15.50 to $23.50	42,000	
Spillway gates, 900,000 lbs. at $0.10	90,000	
Sluiceways	50,000	
Drilling and grouting foundation	30,000	5,715,000
Lands and improvements flooded	1,500,000	1,500,000
Miscellaneous:		
Construction railroad	270,000	
Construction and permanent camps	200,000	470,000
Subtotal, dam and reservoir		$7,919,000
Administration and engineering at 10%		792,000
Contingencies at 15%		1,188,000
Interest during construction		715,000
Total cost of dam and reservoir		$10,614,000
FLOOD CONTROL FEATURES—		
Trash racks	$20,000	$20,000
Reinforced concrete, 3,500 cu. yds. at $15.00 to $25.00	62,000	62,000
Gates, 10—10′ x 10′ sluice gates with hoists	60,000	60,000
Subtotal, flood control features		$142,000
Administration and engineering at 10%		14,000
Contingencies at 15%		21,000
Interest during construction		7,000
Total cost of flood control features		$184,000
POWER PLANT—		
Intake structure	$68,000	$68,000
Penstock:		
Tunnel excavation, 10,800 cu. yds. at $11.00 to $13.50	$122,000	
Tunnel timbering	22,000	
Concrete tunnel lining, 5,150 cu. yds. at $20.00	103,000	
Reinforcing steel 100,000 lbs. at $0.055	6,000	
Steel pipes, 825,000 lbs. at $0.085	70,000	
Reinforced concrete	5,000	328,000
Buildings and equipment, 30,000 k.v.a. at $35.00	1,050,000	1,050,000
Subtotal, power plant		$1,514,000
Administration and engineering at 10%		152,000
Contingencies at 15%		227,000
Interest during construction		105,000
Total cost of power plant		$1,998,00
Grand total cost dam, reservoir, flood control features and power plant		**$12,796,000**

Interest during construction at 6 per cent

Total cost of dam and reservoir	$10,863,000
Total cost of flood control features	186,000
Total cost of power plant	2,035,000
Grand total cost of dam, reservoir, flood control features and power plant	**$13,084,000**

Webber Creek reservoir.

The dam for the Webber Creek reservoir is an overflow gravity-concrete type, the same as for the Pilot Creek dam. It is shown on Plate XII, "Webber Creek dam with power plant." Its maximum height is 90 feet above low water level. It is estimated that 10 feet would be required to be stripped from the stream bed, 15 feet on the left abutment and 20 feet on the right abutment to secure a suitable foundation for the dam. A flow of 115,000 second-feet could be passed over the dam with a depth of 20 feet on the crest. No crest gates or sluiceways are provided in the dam. The power house is located 4300 feet downstream from the dam. A concrete-lined tunnel 2650 feet long and 10 feet in diameter would convey water to the power house. It has a capacity of 800 second-feet. The tunnel divides at the lower end into two steel penstocks, each 86 inches in diameter, which deliver water to two constant head reaction turbines directly connected to generators. The installed capacity of the plant is 10,000 k.v.a. with a plant load factor of 0.75 and 13,000 k.v.a. with a plant load factor of 0.60. The estimate of cost with a plant installation of 10,000 k.v.a. is set forth in Table 76, with interest during construction at 4½ and 6 per cent, State and private financing, respectively. This estimate together with one for a power plant installation of 13,000 k.v.a. is summarized in Table 77.

PLATE XII

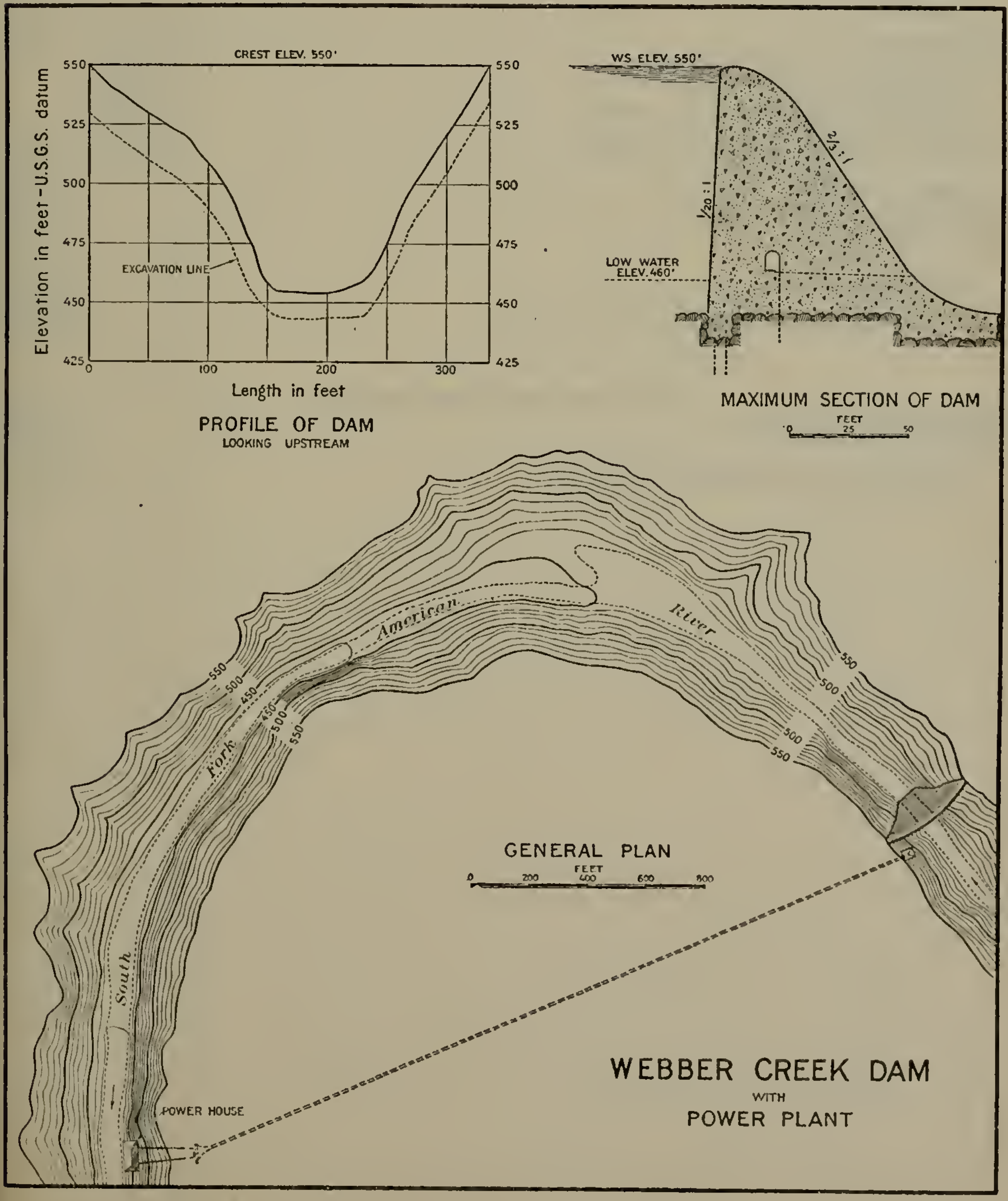


TABLE 76. ESTIMATED COST OF WEBBER CREEK RESERVOIR AND POWER PLANT

Height of dam, 90 feet — Overflow dam

Installed capacity of power plant, 10,000 k. v. a. P. F. = 0.80 L. F. = 0.75

Interest during construction at $4\frac{1}{2}$ per cent

DAM AND RESERVOIR—		
Exploration and core drilling	$10,000	$10,000
Diversion of river during construction	50,000	50,000
Clearing of reservoir site, 200 acres at $25.00	5,000	5,000
Excavation for dam, 15,000 cu. yds. at $2.50 to $5.00	50,000	
Mass concrete, 36,000 cu. yds. at $6.75	243,000	
Drilling and grouting foundation	8,000	301,000
Lands and improvements flooded	10,000	10,000
Miscellaneous:		
Construction and permanent camps	50,000	
Construction railroad	30,000	80,000
Subtotal, dam and reservoir		$456,000
Administration and engineering at 10%		46,000
Contingencies at 15%		68,000
Interest during construction		20,000
Total cost of dam and reservoir		$590,000
POWER PLANT—		
Intake structure	$20,000	$20,000
Penstock:		
Tunnel excavation, 11,800 cu. yds. at $11.00	130,000	
Tunnel timbering	12,000	
Concrete tunnel lining, 5,400 cu. yds. at $20.00	108,000	
Steel pipes, 190,000 lbs. at $0.15	28,000	278,000
Buildings and equipment, 10,000 k.v.a. at $35.00	350,000	350,000
Subtotal, power plant		$648,000
Administration and engineering at 10%		65,000
Contingencies at 15%		97,000
Interest during construction		28,000
Total cost of power plant		$838,000
Grand total cost of dam, reservoir and power plant		**$1,428,000**

Interest during construction at 6 per cent

Total cost of dam and reservoir	$596,000
Total cost of power plant	847,000
Grand total cost of dam, reservoir and power plant	**$1,443,000**

TABLE 76. ESTIMATED COST OF WEBBER CREEK RESERVOIR AND POWER PLANT

Height of dam, 90 feet — Overflow dam

Installed capacity of power plant, 10,000 k. v. a. P. F. = 0.80 L. F. = 0.75

Interest during construction at $4\frac{1}{2}$ per cent

DAM AND RESERVOIR—		
Exploration and core drilling	$10,000	$10,000
Diversion of river during construction	50,000	50,000
Clearing of reservoir site, 200 acres at $25.00	5,000	5,000
Excavation for dam, 15,000 cu. yds. at $2.50 to $5.00	50,000	
Mass concrete, 36,000 cu. yds. at $6.75	243,000	
Drilling and grouting foundation	8,000	301,000
Lands and improvements flooded	10,000	10,000
Miscellaneous:		
Construction and permanent camps	50,000	
Construction railroad	30,000	80,000
Subtotal, dam and reservoir		$456,000
Administration and engineering at 10%		46,000
Contingencies at 15%		68,000
Interest during construction		20,000
Total cost of dam and reservoir		$590,000
POWER PLANT—		
Intake structure	$20,000	$20,000
Penstock:		
Tunnel excavation, 11,800 cu. yds. at $11.00	130,000	
Tunnel timbering	12,000	
Concrete tunnel lining, 5,400 cu. yds. at $20.00	108,000	
Steel pipes, 190,000 lbs. at $0.15	28,000	278,000
Buildings and equipment, 10,000 k.v.a. at $35.00	350,000	350,000
Subtotal, power plant		$648,000
Administration and engineering at 10%		65,000
Contingencies at 15%		97,000
Interest during construction		28,000
Total cost of power plant		$838,000
Grand total cost of dam, reservoir and power plant		**$1,428,000**

Interest during construction at 6 per cent

Total cost of dam and reservoir	$596,000
Total cost of power plant	847,000
Grand total cost of dam, reservoir and power plant	**$1,443,000**

TABLE 77. ESTIMATED COST OF CONSOLIDATED DEVELOPMENT

Folsom reservoir—
- Height of dam, 190 feet
- Capacity of reservoir, 355,000 acre-feet
- Capacity of flood control outlets, 100,000 second-feet
- Installed capacity of power plant,
  - Auburn and Coloma reservoirs not constructed,
    - 43,000 k.v.a. P F. =0.80 L.F. =0.75
    - 35,000 k.v.a. P.F. =0.80 L.F. =1.00
  - Auburn and Coloma reservoirs constructed,
    - 54,000 k.v a. P F. =0.80 L F. =0.75
    - 45,000 k.v.a. P.F. =0.80 L F. =1.00

Auburn reservoir—
- Height of dam, 390 feet
- Capacity of reservoir, 598,000 acre-feet
- Capacity of flood control outlets, 50,000 second-feet
- Installed capacity of power plant,
  - 82,000 k.v.a. P F. =0 80 L.F. =0.60
  - 66,000 k.v.a. P.F. =0.80 L F. =0.75

Pilot Creek reservoir—
- Height of dam, 110 feet
- Installed capacity of power plant,
  - 23,000 k.v.a. P F. =0.80 L F. =0.60
  - 19,000 k.v.a. P F. =0.80 L F. =0.75

Coloma reservoir—
- Height of dam, 340 feet
- Capacity of reservoir, 766,000 acre-feet
- Capacity of flood control outlets, 30,000 second-feet
- Installed capacity of power plant,
  - 37,000 k.v.a P F. =0.80 L.F. =0.60
  - 30,000 k.v.a. P F. =0.80 L.F. =0.75

Webber Creek reservoir—
- Height of dam, 90 feet
- Installed capacity of power plant,
  - 13,000 k.v.a. P F. =0.80 L F. =0 60
  - 10,000 k.v.a. P F. =0.80 L.F. =0.75

Cost with interest during construction at 4½ per cent

Unit	Dam	Lands and improvements and clearing of reservoir site	Power plant		Additional cost for flood control features		Total cost	
			L.F.=0.60*	L.F.=0.75	L.F.=0.60*	L.F.=0.75	L.F.=0.60*	L.F.=0.75
Folsom Reservoir (Initial development. Auburn and Coloma reservoirs not constructed)	$6,633,000	$1,696,000	*$2,400,000	$2,797,000	*$558,000	$558,000	*$11,287,000	$11,684,000
Folsom Reservoir	$6,633,000	$1,696,000	*$2,949,000	$3,390,000	*$563,000	$563,000	*$11,841,000	$12,282,000
Auburn Reservoir	11,597,000	1,528,000	4,357,000	3,633,000	447,000	447,000	17,929,000	17,205,000
Pilot Creek Reservoir	886,000	53,000	1,205,000	1,024,000	.....	.....	2,144,000	1,963,000
Total, second stage of development	$19,116,000	$3,277,000	$8,511,000	$8,047,000	$1,010,000	$1,010,000	$31,914,000	$31,450,000
Coloma Reservoir	8,234,000	2,312,000	2,220,000	1,996,000	252,000	252,000	13,018,000	12,796,000
Webber Creek Reservoir	570,000	20,000	973,000	838,000	.....	.....	1,563,000	1,428,000
Grand total, complete development	**$27,920,000**	**$5,609,000**	**$11,704,000**	**$10,883,000**	**$1,262,000**	**$1,262,000**	**$46,495,000**	**$45,674,000**

Cost with interest during construction at 6 per cent

Unit	Dam	Lands and improvements and clearing of reservoir site	Power plant		Additional cost for flood control features		Total cost	
			L.F.=0.60*	L.F.=0.75	L.F.=0.60*	L.F.=0.75	L.F.=0.60*	L.F.=0.75
Folsom Reservoir (Initial development. Auburn and Coloma reservoirs not constructed)	$6,735,000	$1,743,000	*$2,441,000	$2,842,000	*$566,000	$568,000	*$11,487,000	$11,888,000
Folsom Reservoir	$6,735,000	$1,743,000	*$2,997,000	$3,444,000	*$573,000	$573,000	*$12,048,000	$12,495,000
Auburn Reservoir	11,818,000	1 578,000	4,418,000	3,686,000	454,000	454,000	18,268,000	17,536,000
Pilot Creek Reservoir	896,000	53,000	1,218,000	1,035,000	.....		2,167,000	1,984,000
Total, second stage of development	$19,449,000	$3,374,000	$8,633,000	$8,165,000	$1,027,000	$1,027,000	$32,483,000	$32,015,000
Coloma Reservoir	8,398,000	2,395,000	2,256,000	2,035,000	256,000	256,000	13,305,000	13,084,000
Webber Creek Reservoir	576,000	20,000	984,000	847,000	.....	.....	1,580,000	1,443,000
Grand total, complete development	**$28,423,000**	**$5,789,000**	**$11,873,000**	**$11,047,000**	**$1,283,000**	**$1,283,000**	**$47 368,000**	**$46,542,000**

* Folsom Power Plant, L.F.=1.00.

Complete development.

The estimated costs of the complete development are assembled in Table 77. Costs are given for interest during construction for both $4\frac{1}{2}$ and 6 per cent, the rates assumed for State and private financing, respectively. It may be noted that two sets of figures are given for the Folsom reservoir. One set is for the condition of Folsom reservoir constructed alone. The other is for the condition of Folsom reservoir constructed either in conjunction with Auburn reservoir or in conjunction with both Auburn and Coloma reservoirs. With these latter reservoirs constructed a larger power plant would be justified at Folsom due to the increased regulated flow. Costs are included for varying power plant load factors. In the proposal of the American River Hydro-electric Company, all plants would be installed for a plant load factor of 0.60 except the Folsom plant, which would be for a plant load factor of 1.00. Estimates have also been made on the basis of all plants being installed for a plant load factor of 0.75.

Under State financing, the total cost of the complete development including flood control features, with the power plants installed for a plant load factor of 0.75, is $45,674,000. This total is divided among the various items as follows: dams, $27,920,000, 61.1 per cent of total cost; reservoir lands and improvements and clearing of reservoir sites, $5,609,000, 12.3 per cent of total cost; power plants, $10,883,000, 23.8 per cent of total cost; and additional cost of flood control features, $1,262,000, 2.8 per cent of total cost. Under private financing, the total estimated cost, with same power plant installation under State financing is $46,542,000. The division of costs for the various items are practically in the same proportion as under State financing.

CHAPTER X

ANNUAL COST OF CONSOLIDATED DEVELOPMENT

The annual cost of the three stages of the consolidated development has been estimated for various methods of reservoir operation, both with and without inclusion of flood control features and under both State and private financing. The annual costs as set forth in the tables that follow are based on the units given in Table 78.

TABLE 78. BASIS OF ESTIMATED ANNUAL COST OF CONSOLIDATED DEVELOPMENT

Item	State financing and operation	Private financing and operation
Return or interest, in per cent of capital	4.5	7.5
Amortization of state bonds (40 year sinking fund basis), in per cent of capital	1.05	0
Depreciation—		
Lands and improvements, in per cent of capital	0	0
Dams, in per cent of capital	0.3	0.3
Spillway gates, flood control gates and appurtenances, in per cent of capital	1.05	0.65
Power plant (40 year sinking fund basis), in per cent of capital	1.05	0.65
Taxes—		
State, in per cent of capital	0	1.35
Federal, in per cent of capital	0	0.40
Operating expenses and maintenance—		
Dam and reservoir, in per cent of capital	0.40	0.40
Power plant, in dollars per k.v.a. of installed capacity	1.00	1.00

Under State ownership and financing, the interest rate is 4½ per cent per annum which is about one-half per cent higher than the interest bearing rate of the recent State bond issues. The return of 7.5 per cent given for private financing is slightly above the rate of return allowed recently by the State Railroad Commission on investments of privately-owned electric utilities. The amortization of State bonds is based on a life of 40 years and is estimated on a sinking fund basis at an interest rate of 4 per cent per annum. This would be the average annual cost for retirement of bonds.

Depreciation on the dam has been estimated at 0.3 per cent. For the spillway and flood control gates and appurtenances, and power plant, depreciation has been estimated at 1.05 and 0.65 per cent of capital cost for State and private financing and ownership, respectively, assuming a forty years' life on a sinking fund of 4 per cent for State and 6 per cent for private financing.

State taxes for private ownership have been estimated on the capital cost including lands and improvements. Under the present method of taxing electric utilities, a private utility would pay the same State tax as it would if the plant were constructed and owned by it, the tax being determined as a per cent of the total gross revenue of the utility. For comparison with costs of other power, therefore, the cost has been estimated excluding State taxes. The present State tax is 7.5 per cent of the gross revenue. Assuming revenue would equal total cost, the resultant tax rate would be approximately 0.72 of one per cent of the capital. Since this basis can hardly be expected to continue indefinitely, a rate of 1.35 per cent of capital cost has been used, which on the average would be approximately equal to the tax rate on general property in the State.

Operating and maintenance expenses, which would include not only local but also general expenses and contingencies have been estimated at 0.4 per cent of capital cost of the dam and reservoir and $1 per k.v.a. for the power plant, for both State and private ownership and operation.

Table 79 sets forth annual costs in total, in per cent of capital cost and per kilowatt hour of power produced at the plants under the State financing, for the units operated in accord with the schedule of water release to develop maximum primary power and with power installations based on a 75 per cent load factor and both with and without inclusion of flood control features.

The annual cost, in per cent of capital cost, ranges from 6.7 to 6.8 both with and without flood control features for all three stages of the development and for each kilowatt hour of power produced at the plants from 4.3 mills for the second stage and complete development, without flood control features, to 5.1 mills for the initial stage of development with flood control features. Corresponding figures under private financing are higher and are given in Table 80. The annual cost in per cent of capital cost is about 10.3 per cent for all stages of development both with and without flood control features when State taxes are included and about 9.0 per cent, excluding State taxes. The annual cost of each kilowatt hour produced ranges from 5.8 mills for the second stage of development, without flood control features and excluding State taxes, to 8.0 mills for initial development with flood control features and including State taxes.

Tables 81 and 82 give similar data for the schedule of water release and for power installations proposed by the American River Hydroelectric Company. Under State financing (Table 81) the annual cost in per cent of capital cost ranges from 6.6 per cent for the initial stage of development to 6.8 per cent for the second stage and complete developments, both with and without flood control features. The cost of each kilowatt hour produced at the plants ranges from 3.7 mills for the second stage without flood control features to 4.6 mills for the initial development with flood control features. Under private financing (Table 82) the annual cost in per cent of capital cost is about 10.3 per cent for all stages of development, both with and without flood control features, when State taxes are included, and about 9.0 per cent, excluding State taxes. The annual cost of each kilowatt hour produced ranges from 5.0 mills for the second stage of development, without flood control features and excluding State taxes, to 7.3 mills for the initial stage of development with flood control features and including State taxes.

The annual costs given in Tables 79, 80, 81 and 82, together with annual costs of other methods of reservoir operation, are summarized in Tables 83 and 84

TABLE 79. ESTIMATED ANNUAL COST OF CONSOLIDATED DEVELOPMENT

Operated primarily for generation of power with schedule of water release to develop maximum primary power

STATE FINANCING

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant,
Auburn and Coloma reservoirs not constructed,
43,000 k.v.a. P.F. =0.80; L.F. =0.75
Auburn and Coloma reservoirs constructed,
54,000 k.v.a. P.F. =0.80; L.F. 0.75
Tailrace elevation of power plant, 200 feet

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant,
66,000 k.v.a. P.F. =0.80 L.F. =0.75

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant,
30,000 k.v.a. P.F. =0.80 L.F. =0.75

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant,
19,000 k.v.a. P.F. =0.80 L.F. =0.75

Webber Creek reservoir—
Height of dam, 90 feet
Installed capacity of power plant
10,000 k.v.a. P.F. =0.80 L.F. =0.75

Average annual power output—
Initial development, 153,700,000 kilowatt hours
Second stage of development 481,100,000 kilowatt hours
Complete development, 689,500,000 kilowatt hours

Item	Cost without Flood Control Features						Cost with Flood Control Features. Capacity of flood control outlets: Folsom reservoir 100,000 second-feet; Auburn reservoir 50,000 second-feet; Coloma reservoir 30,000 second-feet					
	Initial Development. Folsom reservoir and power plant. Auburn and Coloma reservoirs not constructed		Second Stage of Development. Folsom, Auburn and Pilot Creek reservoirs and power plants. Coloma reservoir not constructed		Complete Development. Folsom, Auburn, Pilot Creek, Coloma and Webber Creek reservoirs and power plants		Initial Development. Folsom reservoir and power plant. Auburn and Coloma reservoirs not constructed		Second Stage of Development. Folsom, Auburn and Pilot Creek reservoirs and power plants. Coloma reservoir not constructed		Complete Development. Folsom, Auburn, Pilot Creek, Coloma and Webber Creek reservoirs and power plants	
	Capital cost	Annual cost	Capital cost	Annual cost	Capital cost	Annual cost	Capital cost	Annual cost	Capital cost	Annual cost	Capital cost	Annual cost
Reservoir and dam	$8,529,000		$22,393,000		$33,529,000		$8,801,000		$23,280,000		$34,668,000	
Interest		$375,000		$1,008,000		$1,509,000		$396,000		$1,048,000		$1,560,000
Amortization		87,000		235,000		352,000		92,000		241,000		364,000
Depreciation		23,000		64,000		92,000		25,000		66,000		96,000
Operation and maintenance		33,000		90,000		134,000		35,000		93,000		139,000
Total—reservoir and dam		$518,000		$1,397,000		$2,087,000		$548,000		$1,451,000		$2,159,000

Power plant	$2,797,000		$8,047,000		$10,883,000		$2,883,000		$8,170,000		$11,006,000	
Interest		$126,000		$362,000		$490,000		$130,000		$368,000		$495,000
Amortization		29,000		85,000		114,000		30,000		86,000		116,000
Depreciation		29,000		85,000		114,000		30,000		86,000		116,000
Operation and maintenance		43,000		139,000		179,000		43,000		139,000		179,000
Total—power plant		$227,000		$671,000		$897,000		$233,000		$679,000		$906,000
Reservoir, dam and power plant	$11,126,000		$30,440,000		$44,412,000		$11,684,000		$31,450,000		$45,674,000	
Interest		$501,000		$1,570,000		$1,999,000		$526,000		$1,416,000		$2,055,000
Amortization		116,000		320,000		466,000		122,000		330,000		480,000
Depreciation		52,000		149,000		206,000		55,000		152,000		212,000
Operation and maintenance		76,000		229,000		313,000		78,000		232,000		318,000
Grand total—annual cost		$745,000		$2,068,000		$2,984,000		$781,000		$2,130,000		$3,065,000
Annual cost, in per cent of capital cost		6.7		6.8		6.7		6.7		6.8		6.7
Annual cost per kilowatt hour produced, in mills		4.9		4.3		4.3		5.1		4.4		4.5

TABLE 80. ESTIMATED ANNUAL COST OF CONSOLIDATED DEVELOPMENT

Operated primarily for generation of power with schedule of water release to develop maximum primary power

PRIVATE FINANCING

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant,
Auburn and Coloma reservoirs not constructed, 43,000 k.v.a. P.F. =0.80; L.F. =0.75
Auburn and Coloma reservoirs constructed 54,000 k.v.a. P.F. =0.80; L.F. 0.75
Tailrace elevation of power plant, 200 feet

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant, 66,000 k.v.a. P.F. =0.80 L.F. =0.75

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant, 19,000 k.v.a. P.F. =0.80 L.F. =0.75

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant, 30,000 k.v.a. P.F. =0.80 L.F. =0.75

Webber Creek reservoir—
Height of dam, 90 feet
Installed capacity of power plant, 10,000 k.v.a. P.F. =0.80 L.F. =0.75

Average annual power output without and with flood control—
Initial development, 153,700,000 kilowatt hours
Second stage of development 481,100,000 kilowatt hours
Complete development, 689,500,000 kilowatt hours

Item	Cost without Flood Control Features						Cost with Flood Control Features Capacity of flood control outlets: Folsom reservoir 100,000 second-feet; Auburn reservoir 50,000 second-feet; Coloma reservoir 30,000 second-feet					
	Initial Development Folsom reservoir and power plant. Auburn and Coloma reservoirs not constructed		Second Stage of Development Folsom, Auburn and Pilot Creek reservoirs and power plants. Coloma reservoir not constructed		Complete Development Folsom, Auburn, Pilot Creek, Coloma and Webber Creek reservoirs and power plants		Initial Development Folsom reservoir and power plant. Auburn and Coloma reservoirs not constructed		Second Stage of Development Folsom, Auburn and Pilot Creek reservoirs and power plants. Coloma reservoir not constructed		Complete Development Folsom, Auburn, Pilot Creek, Coloma and Webber Creek reservoirs and power plants	
	Capital cost	Annual cost	Capital cost	Annual cost	Capital cost	Annual cost	Capital cost	Annual cost	Capital cost	Annual cost	Capital cost	Annual cost
Reservoir and dam	$8,478,000		$22 823 000		$34,212,000		$8,958,000		$23,721,000		$35,369,000	
Return		$636,000		$1,712,000		$2,566,000		$672,000		$1,779,000		$2,653,000
Depreciation		22,000		62,000		89,000		23,000		64,000		93,000
State tax		114,000		308,000		462,000		121,000		320,000		477,000
Federal tax		34,000		91,000		137,000		36,000		95,000		141,000
Operation and maintenance		34,000		91,000		137,000		36,000		95,000		141,000
Total—reservoir and dam		$840,000		$2,264,000		$3,391,000		$888,000		$2,353,000		$3,505,000

Power plant	$2,842,000		$8,165,000		$11,017,000		$2,930,000		$8,291,000		$11,173,000	
Return		$213,000		$612,000		$829,000		$220,000		$622,000		$838,000
Depreciation		18,000		53,000		72,000		19,000		54,000		73,000
State tax		38,000		110,000		149,000		40,000		112,000		151,000
Federal tax		11,000		33,000		44,000		12,000		33,000		45,000
Operation and maintenance		43,000		139,000		179,000		43,000		139,000		179,000
Total—power plant		$323,000		$947,000		$1,273,000		$334,000		$960,000		$1,286,000
Reservoir, dam and power plant	$11,320,000		$30,988,000		$45,259,000		$11,888,000		$32,015,000		$46,512,000	
Return		$849,000		$2,324,000		$3,395,000		$892,000		$2,401,000		$3,491,000
Depreciation		40,000		115,000		161,000		42,000		118,000		166,000
State tax		152,000		418,000		611,000		161,000		432,000		628,000
Federal tax		45,000		124,000		181,000		48,000		128,000		186,000
Operation and maintenance		77,000		230,000		316,000		79,000		234,000		320,000
Grand total, annual cost—												
Including state tax		$1,163,000		$3,211,000		$4,664,000		$1,222,000		$3,313,000		$4,791,000
Excluding state tax		$1,011,000		$2,793,000		$4,053,000		$1,061,000		$2,881,000		$4,163,000
Annual cost, in per cent of capital cost—												
Including state tax		10.3		10.4		10.3		10.3		10.4		10.3
Excluding state tax		8.9		9.0		9.0		8.9		9.0		8.9
Annual cost per kilowatt hour produced, in mills—												
Including state tax		7.6		6.7		6.8		8.0		6.9		7.0
Excluding state tax		6.6		5.8		5.9		6.9		6.0		6.0

TABLE 81. ESTIMATED ANNUAL COST OF CONSOLIDATED DEVELOPMENT

Operated primarily for the generation of power with water release in accord with schedule proposed by American River Hydro-electric Company

STATE FINANCING

Folsom reservoir—
Height of dam, 190 feet
Capacity of reservoir, 355,000 acre-feet
Installed capacity of power plant,
Auburn and Coloma reservoirs not constructed, 35,000 k.v.a. P.F. =0.80; L.F. =1.00
Auburn and Coloma reservoirs constructed, 45,000 k.v.a. P.F. =0.80; L.F. 1.00
Tailrace elevations of power plant, 207 feet and 162 feet

Auburn reservoir—
Height of dam, 390 feet
Capacity of reservoir, 598,000 acre-feet
Installed capacity of power plant, 82,000 k.v.a. P.F. =0.80 L.F. =0.60

Pilot Creek reservoir—
Height of dam, 110 feet
Installed capacity of power plant, 23,000 k.v.a. P.F. =0.80 L.F. =0.60

Coloma reservoir—
Height of dam, 340 feet
Capacity of reservoir, 766,000 acre-feet
Installed capacity of power plant, 37,000 k.v.a. P.F. =0.80 L.F. =0.60

Webber Creek reservoir—
Height of dam, 90 feet
Installed capacity of power plant, 13,000 k.v.a. P.F. =0.80 L.F. =0.60

Average annual power output, without flood control—
Initial development, 160,200,000 kilowatt hours
Second stage of development, 569,200,000 kilowatt hours
Complete development, 773,100,000 kilowatt hours

Average annual power output with flood control—
Initial development, 161,100,000 kilowatt hours
Second stage of development, 567,000,000 kilowatt hours
Complete development, 764,200,000 kilowatt hours

Item	Cost without Flood Control Features						Cost with Flood Control Features. Capacity of flood control outlets: Folsom reservoir 100,000 second-feet; Auburn reservoir 50,000 second-feet; Coloma reservoir 30,000 second-feet					
	Initial Development. Folsom reservoir and power plant. Auburn and Coloma reservoirs not constructed		Second Stage of Development. Folsom, Auburn and Pilot Creek reservoirs and power plants. Coloma reservoir not constructed		Complete Development. Folsom, Auburn, Pilot Creek, Coloma and Webber Creek reservoirs and power plants		Initial Development. Folsom reservoir and power plant. Auburn and Coloma reservoirs not constructed		Second Stage of Development. Folsom, Auburn and Pilot Creek reservoirs and power plants. Coloma reservoir not constructed		Complete Development. Folsom, Auburn, Pilot Creek, Coloma and Webber Creek reservoirs and power plants	
	Capital cost	Annual cost	Capital cost	Annual cost	Capital cost	Annual cost	Capital cost	Annual cost	Capital cost	Annual cost	Capital cost	Annual cost
Reservoir and dam	$8,329,000		$22,393,000		$53,529,000		$8,801,000		$23,280,000		$34,668,000	
Interest		$375,000		$1,008,000		$1,509,000		$396,000		$1,048,000		$1,560,000
Amortization		87,000		235,000		352,000		92,000		244,000		364,000
Depreciation		23,000		64,000		92,000		25 000		66,000		96,000
Operation and maintenance		33,000		90,000		134,000		35,000		93,000		139,000
Total—reservoir and dam		$518,000		$1,397,000		$2,087,000		$548,000		$1,451,000		$2,159,000

Power plant	$2,400,000		$8,511,000		$11,704,000		$2,486,000		$8,634,000		$11,827,000	
Interest		$108,000		$383,000		$527,000		$112,000		$389,000		$532,000
Amortization		25,000		89,000		123,000		26,000		91,000		124,000
Depreciation		25,000		89,000		123,000		26,000		91,000		124,000
Operation and maintenance		35,000		150,000		200,000		35,000		150,000		200,000
Total—power plant		$193,000		$711,000		$973,000		$199,000		$721,000		$980,000
Reservoir, dam and power plant	$10,729,000		$30,904,000		$45,233,000		$11,287,000		$31,914,000		$46,495,000	
Interest		$483,000		$1,391,000		$2,036,000		$508,000		$1,437,000		$2,092,000
Amortization		112,000		324,000		475,000		118,000		335,000		488,000
Depreciation		48,000		153,000		215,000		51,000		157,000		220,000
Operation and maintenance		68,000		240,000		334,000		70,000		243,000		339,000
Grand total—annual cost		$711,000		$2,108,000		$3,060,000		$747,000		$2,172,000		$3,139,000
Annual cost, in per cent of capital cost		6.6		6.8		6.8		6.6		6.8		6.8
Annual cost per kilowatt hour produced, in mills		4.4		3.7		4.0		4.6		3.8		4.1

TABLE 82. ESTIMATED ANNUAL COST OF CONSOLIDATED DEVELOPMENT

Operated primarily for generation of power with water release in accord with schedule proposed by American River Hydro-electric Company

PRIVATE FINANCING

Folsom reservoir—
- Height of dam, 190 feet
- Capacity of reservoir, 355,000 acre-feet
- Installed capacity of power plant,
  - Auburn and Coloma reservoirs not constructed, 35,000 k.v.a. P.F. =0.80; L.F. =1.00
  - Auburn and Coloma reservoirs constructed, 45,000 k.v.a. P.F. =0.80; L.F. =1.00
- Tailrace elevations of power plant, 207 feet and 162 feet

Auburn reservoir—
- Height of dam, 390 feet
- Capacity of reservoir, 598,000 acre-feet
- Installed capacity of power plant, 82,000 k.v.a. P.F. =0.80 L.F. =0.60

Pilot Creek reservoir—
- Height of dam, 110 feet
- Installed capacity of power plant, 23,000 k.v.a. P.F. =0.80 L.F. =0.60

Coloma reservoir—
- Height of dam, 340 feet
- Capacity of reservoir, 766,000 acre-feet
- Installed capacity of power plant, 37,000 k.v.a. P.F. =0.80 L.F. =0.60

Webber Creek reservoir—
- Height of dam, 90 feet
- Installed capacity of power plant, 13,000 k.v.a. P.F. =0.80 L.F. =0.60

Average annual power output without flood control—
- Initial development, 160,200,000 kilowatt hours
- Second stage of development, 569,200,000 kilowatt hours
- Complete development, 773,100,000 kilowatt hours

Average annual power output with flood control—
- Initial development, 161,100,000 kilowatt hours
- Second stage of development, 567,000,000 kilowatt hours
- Complete development, 764,200,000 kilowatt hours

Item	Cost without Flood Control Features						Cost with Flood Control Features. Capacity of flood control outlets: Folsom reservoir 100,000 second-feet; Auburn reservoir 50,000 second-feet; Coloma reservoir 30,000 second-feet					
	Initial Development Folsom reservoir and power plant. Auburn and Coloma reservoirs not constructed		Second Stage of Development Folsom, Auburn and Pilot Creek reservoirs and power plants. Coloma reservoir not constructed		Complete Development Folsom, Auburn, Pilot Creek, Coloma and Webber Creek reservoirs and power plants		Initial Development Folsom reservoir and power plant. Auburn and Coloma reservoirs not constructed		Second Stage of Development Folsom, Auburn and Pilot Creek reservoirs and power plants. Coloma reservoir not constructed		Complete Development Folsom, Auburn, Pilot Creek, Coloma and Webber Creek reservoirs and power plants	
	Capital cost	Annual cost	Capital cost	Annual cost	Capital cost	Annual cost	Capital cost	Annual cost	Capital cost	Annual cost	Capital cost	Annual cost
Reservoir and dam	$8,478,000		$22,823,000		$34,212,000		$8,958,000		$23,724,000		$35,369,000	
Return		$636,000		$1,712,000		$2,566,000		$672,000		$1,779,000		$2,653,000
Depreciation		22,000		62,000		89,000		23,000		64,000		93,000
State tax		114,000		308,000		462,000		121,000		320,000		477,000
Federal tax		34,000		91,000		137,000		36,000		95,000		141,000
Operation and maintenance		34,000		91,000		137,000		36,000		95,000		141,000
Total—reservoir and dam		$810,000		$2,264,000		$3,391,000		$888,000		$2,353,000		$3,505,000

Power plant	$2,441,000		$8,633,000		$11,873,000		$2,529,000		$8,759,000		$11,999,000	
Return		$183,000		$647,000		$890,000		$190,000		$657,000		$900,000
Depreciation		16,000		56,000		77,000		16,000		57,000		78,000
State tax		33,000		117,000		160,000		34,000		118,000		162,000
Federal tax		10,000		35,000		47,000		10,000		35,000		48,000
Operation and maintenance		35,000		150,000		200,000		35,900		150,000		200,000
Total—power plant		$277,000		$1,005,000		$1,374,000		$285,000		$1,017,000		$1,388,000
Reservoir, dam and power plant	$10,919,000		$31,456,000		$46,085,000		$11,487,000		$32,483,000		$47,368,000	
Return		$819,000		$2,359,000		$3,456,000		$862,000		$2,436,000		$3,553,000
Depreciation		38,000		118,000		166,000		39,000		121,000		171,000
State tax		147,000		425,000		622,000		155,000		438,000		639,000
Federal tax		44,000		126,000		184,000		46,000		130,000		189,000
Operation and maintenance		69,000		241,000		337,000		71,000		245,000		341,000
Grand total, annual cost—												
Including state tax		$1,117,000		$3,269,000		$4,765,000		$1,173,000		$3,370,000		$4,893,000
Excluding state tax		$970,000		$2,844,000		$1,143,000		$1,018,000		$2,932,000		$1,254,000
Annual cost, in per cent of capital cost—												
Including state tax		10.2		10.4		10.3		10.2		10.4		10.3
Excluding state tax		8.9		9.0		9.0		8.9		9.0		9.0
Annual cost per kilowatt hour produced, in mills—												
Including state tax		7.0		5.7		6.2		7.3		5.9		6.5
Excluding state tax		6.1		5.0		5.4		6.3		5.2		5.6

TABLE 83. ANNUAL COST OF CONSOLIDATED DEVELOPMENT

Water release to develop maximum primary power consistent with other requirements

Method of reservoir operation	Average annual power output in kilowatt hours L.F.=0.75	State financing and operation				Private financing and operation						
		Capital cost	Annual cost	Annual cost in per cent of capital cost	Annual cost per kilowatt hour of power produced in mills	Capital cost	Annual cost		Annual cost in per cent of capital cost		Annual cost per kilowatt hour of power produced in mills	
							Excluding state taxes	Including state taxes	Excluding state taxes	Including state taxes	Excluding state taxes	Including state taxes
Initial Development												
(Folsom reservoir and power plant)												
Power (developing maximum primary power)	153,700,000	$11,126,000	$745,000	6.7	4.9	$11,320,000	$1,011,000	$1,163,000	8.9	10.3	6.6	7.6
Power and flood control (developing maximum primary power consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks)	153,700,000	11,684,000	781,000	6.7	5.1	11,888,000	1,061,000	1,222,000	8.9	10.3	6.9	8.0
Irrigation with incidental power (irrigation yield of 664,000 acre-feet per season, with an average deficiency in seasonal supply of 2.2 per cent of perfect seasonal supply)	143,700,000	11,126,000	745,000	6.7	5.2	11,320,000	1,011,000	1,163,000	8.9	10.3	7.0	8.1
Irrigation and flood control with incidental power (irrigation yield of 664,000 acre-feet per season with an average deficiency in seasonal supply of 2.2 per cent of perfect seasonal supply. Floods controlled to 100,000 second-feet maximum flow at Fairoaks)	143,700,000	11,684,000	781,000	6.7	5.4	11,888,000	1,061,000	1,222,000	8.9	10.3	7.4	8.5
Second Stage of Development												
(Folsom, Auburn and Pilot Creek reservoirs and power plants)												
Power (developing maximum primary power)	481,100,000	30,440,000	2,068,000	6.8	4.3	30,988,000	2,793,000	3,211,000	9.0	10.4	5.8	6.7
Power and flood control (developing maximum primary power consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks)	481,100,000	31,450,000	2,130,000	6.8	4.4	32,015,000	2,881,000	3,313,000	9.0	10.4	6.0	6.9

Irrigation with incidental power (irrigation yield of 1,250,000 acre-feet per season, with an average deficiency in seasonal supply of 2.1 per cent of perfect seasonal supply)	416,000,000	30,440,000	2,068,000	6.8	5.0	30,988,000	2,793,000	3,211,000	9.0	10.4	6.7	7.7
Irrigation and flood control with incidental power (irrigation yield of 1,250,000 acre-feet per season with an average deficiency in seasonal supply of 2.1 per cent of perfect seasonal supply. Floods controlled to 100,000 second-feet maximum flow at Fairoaks)	416,000,000	31,450,000	2,130,000	6.8	5.1	32,015,000	2,881,000	3,313,000	9.0	10.4	6.9	8.0
Complete Development												
(Folsom, Auburn, Pilot Creek, Coloma and Webber Creek reservoirs and power plants)												
Power (developing maximum primary power)	689,500,000	44,412,000	2,981,000	6.7	4.3	45,259,000	4,053,000	4,664,000	9.0	10.3	5.9	6.8
Power and flood control (developing maximum primary power consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks)	689,500,000	45,674,000	3,065,000	6.7	4.5	46,542,000	4,163,000	4,791,000	8.9	10.3	6.0	7.0
Power and salinity control (developing maximum primary power consistent with maintaining an inflow into the delta of the Sacramento and San Joaquin rivers of 5,000 second-feet for salinity control)	652,900,000	44,412,000	2,984,000	6.7	4.6	45,259,000	4,053,000	4,664,000	9.0	10.3	6.2	7.1
Power, flood control and salinity control (developing maximum primary power consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks and maintaining an inflow into the delta of the Sacramento and San Joaquin rivers of 5,000 second-feet for salinity control)	652,900,000	45,674,000	3,065,000	6.7	4.7	46,542,000	4,163,000	4,791,000	8.9	10.3	6.4	7.3
Power, flood control, salinity control and irrigation supply of 1,000 second-feet to San Joaquin Valley (developing maximum primary power consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks, maintaining an inflow into the delta of the Sacramento and San Joaquin rivers of 5,000 second-feet for salinity control, and an irrigation supply of 334,000 acre-feet per season, 1,000 second-feet maximum rate of flow to San Joaquin Valley)	632,300,000	45,674,000	3,065,000	6.7	4.8	46,542,000	4,163,000	4,791,000	8.9	10.3	6.6	7.6

TABLE 83. (Continued.) ANNUAL COST OF CONSOLIDATED DEVELOPMENT

Water release to develop maximum primary power consistent with other requirements

Method of reservoir operation	Average annual power output in kilowatt hours L.F.=0.75	State financing and operation				Private financing and operation						
		Capital cost	Annual cost	Annual cost in per cent of capital cost	Annual cost per kilowatt hour of power produced in mills	Capital cost	Annual cost		Annual cost in per cent of capital cost		Annual cost per kilowatt hour of power produced in mills	
							Excluding state taxes	Including state taxes	Excluding state taxes	Including state taxes	Excluding state taxes	Including state taxes
Complete Development—Continued												
(Folsom, Auburn, Pilot Creek, Coloma and Webber Creek reservoirs and power plants)—Continued												
Power, flood control, salinity control and irrigation supply of 3,000 second-feet to San Joaquin Valley (developing maximum power output consistent with controlling floods to 100,000 second-feet maximum flow at Fair-oaks, maintaining an inflow into the delta of the Sacramento and San Joaquin rivers of 5,000 second-feet for salinity control, and an irrigation supply of 1,000,000 acre-feet per season with an average deficiency in seasonal supply of 1.4 per cent of a perfect seasonal supply, 3,000 second-feet maximum rate of flow to San Joaquin Valley)	585,700,000	$45,674,000	$3,065,000	6.7	5.2	$46,512,000	$4,163,000	$4,791,000	8.9	10.3	7.1	8.2
Irrigation with incidental power (irrigation yield of 1,757,000 acre-feet per season with an average deficiency in seasonal supply of 2.2 per cent of a perfect seasonal supply)	511,900,000	44,412,000	2,984,000	6.7	5.8	45,259,000	4,053,000	4,664,000	9.0	10.3	7.9	9.1
Irrigation and salinity control with incidental power (irrigation yield of 1,070,000 acre-feet per season with an average deficiency in seasonal supply of 2.2 per cent of a perfect seasonal supply and maintaining an inflow into the delta of the Sacramento and San Joaquin rivers of 5,000 second-feet for salinity control)	543,400,000	44,412,000	2,984,000	6.7	5.5	45,259,000	4,053,000	4,664,000	9.0	10.3	7.5	8.6

TABLE 84. ANNUAL COST OF CONSOLIDATED DEVELOPMENT

Water release in accord with schedule proposed by American River Hydro-electric Company modified to meet other requirements

Method of reservoir operation	Average annual power output in kilowatt hours L.F.=0.75	State financing and operation				Private financing and operation						
		Capital cost	Annual cost	Annual cost in per cent of capital cost	Annual cost per kilowatt hour of power produced in mills	Capital cost	Annual cost		Annual cost in per cent of capital cost		Annual cost per kilowatt hour of power produced in mills	
							Excluding state taxes	Including state taxes	Excluding state taxes	Including state taxes	Excluding state taxes	Including state taxes
Initial Development												
(Folsom reservoir and power plant)												
Power (with water release in accord with schedule proposed by American River Hydro-electric Company)	160,200,000	$10,729,000	$711,000	6.6	4.4	$10,919,000	$970,000	$1,117,000	8.9	10.2	6.1	7.0
Power and flood control (with water release in accord with schedule proposed by American River Hydro-electric Company consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks)	161,100,000	11,287,000	747,000	6.6	4.6	11,487,000	1,018,000	1,173,000	8.9	10.2	6.3	7.3
Second Stage of Development												
(Folsom, Auburn and Pilot Creek reservoirs and power plants)												
Power (with water release in accord with schedule proposed by American River Hydro-electric Company	569,200,000	30,904,000	2,108,000	6.8	3.7	31,456,000	2,844,000	3,269,000	9.0	10.4	5.0	5.7
Power and flood control (with water release in accord with schedule proposed by American River Hydro-electric Company consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks)	567,000,000	31,914,000	2,172,000	6.8	3.8	32,483,000	2,932,000	3,370,000	9.0	10.4	5.2	5.9

TABLE 84. (Continued.) ANNUAL COST OF CONSOLIDATED DEVELOPMENT

Water release in accord with schedule proposed by American River Hydro-electric Company modified to meet other requirements

Method of reservoir operation	Average annual power output in kilowatt hours L.F.=0.75	State financing and operation				Private financing and operation						
		Capital cost	Annual cost	Annual cost in per cent of capital cost	Annual cost per kilowatt hour of power produced in mills	Capital cost	Annual cost		Annual cost in per cent of capital cost		Annual cost per kilowatt hour of power produced in mills	
							Excluding state taxes	Including state taxes	Excluding state taxes	Including state taxes	Excluding state taxes	Including state taxes
Complete Development												
(Folsom, Auburn, Pilot Creek, Coloma and Webber Creek reservoirs and power plants)												
Power (with water release in accord with schedule proposed by American River Hydro-electric Company)	773,100,000	$45,233,000	$3,060,000	6.8	4.0	$46,085,000	$4,143,000	$4,765,000	9.0	10.3	5.4	6.2
Power and flood control (with water release in accord with schedule proposed by American River Hydro-electric Company consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks)	764,200,000	46,495,000	3,139,000	6.8	4.1	47,368,000	4,254,000	4,893,000	9.0	10.3	5.6	6.4
Power and salinity control (with water release in accord with schedule proposed by American River Hydro-electric Company consistent with maintaining an inflow into the delta of the Sacramento and San Joaquin rivers of 5,000 second-feet for salinity control)	42,500,000	45,233,000	3,060,000	6.8	4.1	46,085,000	4,143,000	4,765,000	9.0	10.3	5.6	6.4
Power, flood control and salinity control (with water release in accord with schedule proposed by American River Hydro-electric Company consistent with controlling floods to 100,000 second-feet maximum flow at Fairoaks and maintaining an inflow into the delta of the Sacramento and San Joaquin rivers of 5,000 second-feet for salinity control)	741,200,000	46,495,000	3,139,000	6.8	4.2	47,368,000	4,254,000	4,893,000	9.0	10.3	5.7	6.6

CHAPTER XI

GEOLOGY OF DAM SITES OF CONSOLIDATED DEVELOPMENT

Examinations and subsurface explorations.

A geological examination was made of the dam sites of the consolidated development and a report rendered thereon by Hyde Forbes, geologist, at the request of Mr. Stephen E. Kieffer, representing the American River Hydro-electric Company, with the view of determining the geologic suitability of the sites for the dams proposed.

Mr. Forbes reports the foundation rock at the sites on the north and south forks, which have been used in the estimates in this report, is hard and durable and suitable in all respects for the structures proposed. At the Folsom site, he reports the gelogic conditions are not quite so favorable as for the selected sites on the forks, nevertheless, with usual precautions in stripping and pressure grouting, the site is entirely satisfactory for the dam proposed. Mr. Forbes' report is included in full herein.

Subsurface explorations have been made only of the Folsom site, which was core drilled by the American River Hydro-electric Company, with 35 vertical holes aggregating 1265 feet. These in most instances penetrated solid rock. The sites on the forks have not been drilled.

Geologic report.

The report of Hyde Forbes is as follows:

Mr. Stephen E. Kieffer,
Consulting Engineer,
57 Post Street,
San Francisco.

Dear Sir:

At your request, I made a study in the field during August and September of 1928 of the geologic and topographic conditions obtaining along the North Fork channel of the American River, in the vicinity of Auburn, and the South Fork channel of the American River, from the vicinity of Coloma to Salmon Falls. These river sections contain six proposed dam sites, three on each stream, which were studied in some greater detail. Subsequently, I have investigated the proposed Folsom dam site.

Based upon surface indications as to rock types, as well as general geological and topographical conditions, but subject to later check and corroboration through subsurface exploration, it is my opinion that:

(1) The massive rock spurs through which the rivers have cut their courses offer excellent foundations for the structures proposed at the Lower Auburn and Pilot Creek dam sites on the North Fork of the American River and two proposed sites on the South Fork of the American River at about river bed elevations, 430 feet and 550 feet above sea level, respectively. No major faults occur in the region examined. Shear zones are few, very limited in extent, and at unweathered exposures are found thoroughly strengthened through the deposition of secondary quartz. There is no reason to anticipate that any structural weakness will be revealed upon stripping of the dam sites.

(2) The Lower Auburn dam site occupies a gorge cut by the North Fork of the American River through a massive ridge of hard, compact rock, the joints in which become inconsequental at short distances below ground surface and, in unweathered portions, are closed by quartz deposition. It is probable that unweathered rock will be found at relatively shallow depth on the steep canyon walls. But the topography suggests waterfall conditions during the erosive history of the North Fork of the American River at this point, and it is probable that pot holes of some extent will be found in the rock bottom of the stream.

(3) The Pilot Creek dam site is located upon the North Fork of the American River where it cuts through the most conspicuous topographic feature of the region—a high ridge which strikes northwest-southeast across the region through Pilot Hill. The foundation rock for the proposed structure will be made up of the same material that occurs at the Lower Auburn dam site, capable of entirely fulfilling the requirements as a support for the proposed structures.

(4) The Lower Coloma dam site is located upon the South Fork of the American River at the point its course cuts through the Pilot Hill ridge, described just above. Here topographic and geologic features combine to make an excellent dam site.

(5) Beginning at river bed elevation 430 feet (downstream from Webber Creek) and extending up the South Fork of the American River for several hundred feet is a rock formation that is hard, durable, and difficult to break under blows of a hammer. The stream bed is narrow and the side walls rise abruptly above it the full height of the proposed structure. Detailed surveys will reveal the best topographic location for a dam site within an extensive area whose rock will afford an excellent foundation for a dam, require a minimum of stripping, and should present shallow depth of stream bed materials. This site is designated upon the accompanying map as the Webber Creek site.

(6) An investigation was made of a surveyed area designated as the Upper Auburn dam site. The rock at this point is composed of schist and related metamorphic rocks which are less desirable as a foundation for the proposed major structure but could be made to serve were there no better site available.

(7) The upper Coloma dam site which has been surveyed and considered for some time past was also invesigated. A dam foundation here, however, would be composed of a series of metamorphic rocks which change in physical characteristics and mineral constitutents within relatively narrow zones. One of these zones consists of serpentine which dips beneath the dam site. The rocks are not suited as a foundation for a major structure such as that proposed.

(8) While at the Folsom dam site the topographic and geologic conditions are less favorable as a site for a major structure than those found at the Lower Auburn and Lower Coloma sites, with the usual precautions of complete stripping to solid rock and pressure grouting the foundation, it will prove an entirely satisfactory site for the structure proposed.

The results of the field investigation upon which the above stated conclusions are based, are herewith appended in a report.

Respectfully submitted.

(Signed) HYDE FORBES,
Geologist.

San Francisco, California, January 21, 1929.

GEOLOGIC FEATURES ALONG SECTIONS OF THE NORTH AND SOUTH FORKS OF THE AMERICAN RIVER

The region investigated is one in which occur the oldest of the Sierra rock masses. The formations consist largely of metamorphic rocks derived through dynamic-metamorphism. Intense movement and pressure have altered the original ancient sediments and basic igneous rocks over a wide region. The alteration has effected an increase in crystallization, thus changing the texture and generally increasing the hardness. Within the region younger masses of granitic and other igneous rocks, intrusive in the metamorphics, have caused (due to the great heat of and the escaping vapors from the molten intrusion) a border zone of increased metamorphism or further alteration to exist along the contacts. Consequently the complex nature of the formations derived through these processes requires a field study of a wide area surrounding, as well as a detailed study of the proposed dam sites, in order that a thorough understanding of the rock characteristics may be had.

Waldemar Lindgren, in the earlier publications of the United States Geological Survey, includes the metamorphics and intrusive igneous masses in a broad classification as "Bedrock series" of Pre-Jurassic Age. Sufficient for the present purpose is the fact that the rock formations are ancient, that no major faults have been found in the Bedrock series, and that minor shear zones, faults, and joints have been closed and the mass consolidated through the deposition of secondary quartz in the ages since movement has taken place.

Amphibolite and Amphibolite-schist.

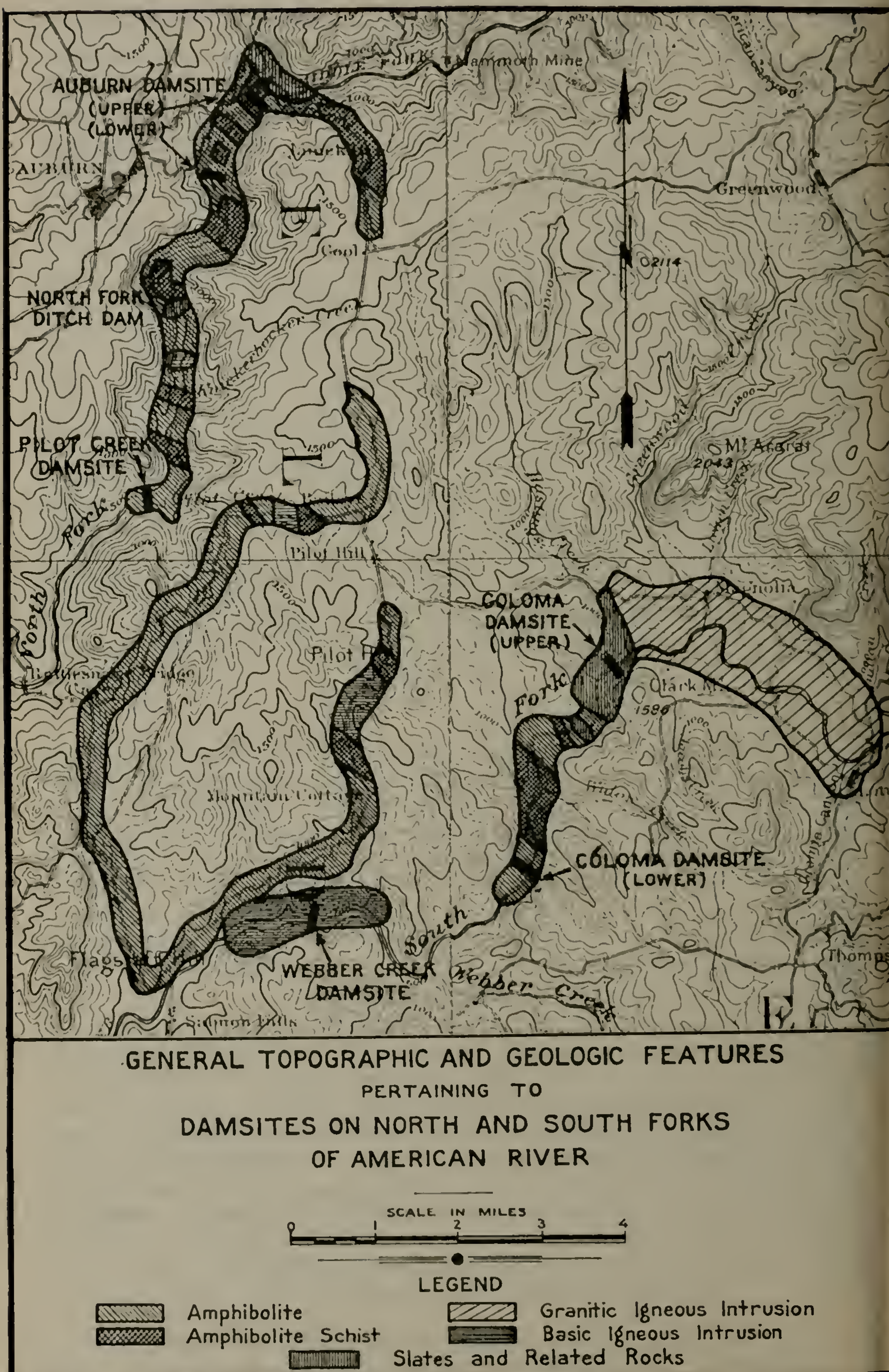
The United States Geological Survey classifies the metamorphics, which make up the greater portion of the region examined, as amphibolite, which designation embraces all phases and modifications within the rock mass. Dynamic metamorphism acting upon basic igneous rock whose chief bisilicate was pyroxene, caused it to pass into hornblendic rocks with more or less development of schistosity. The formation is "banded" through the variation in texture and mineral constituents which occur within relatively short distances, all phases being, however, perfectly crystalline. The trend of the banding is northwest to southeast and the bands dip almost vertically.

Some of the bands are decidedly laminated or foliated due to the parallel arrangement of hornblende crystals. Others present a massive appearance with the schistosity hardly discernable. Certain bands of the hornblende schist have passed into more finely laminated, green chlorite schist which softens to a scaly mass and weathers to the rusty colored clay soil characteristic of the region. Variation of the massive and schistose texture is irregular. The massive phase resembles the original igneous rock, is very hard, durable, and resists erosion and weathering. The bands of massive amphibolite therefore mark the highest mountains and the most continuous ridge spurs.

Topographic development.

Both the North and South forks of the American River cross the amphibolite over the greater portion of the sections examined. In the

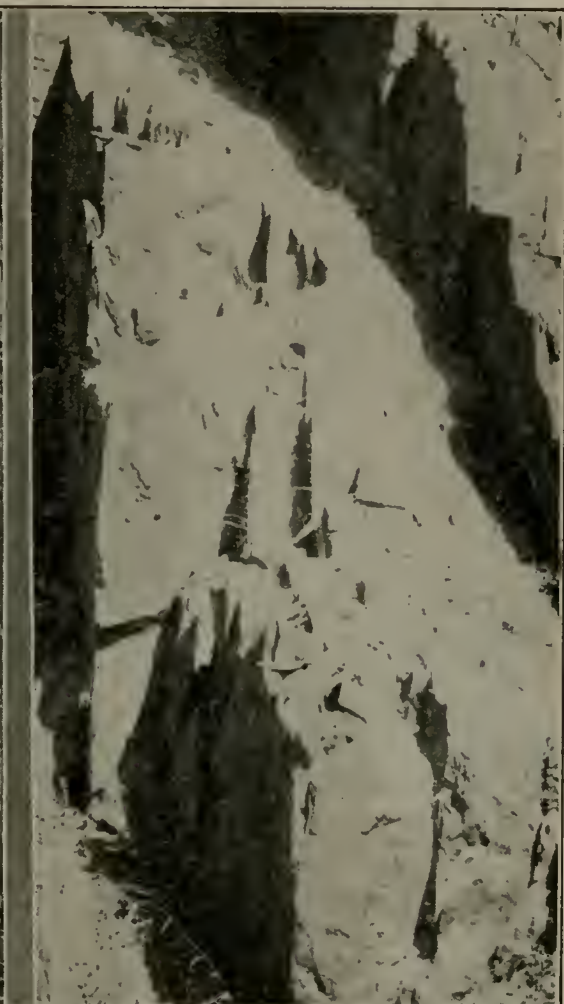
PLATE XIII



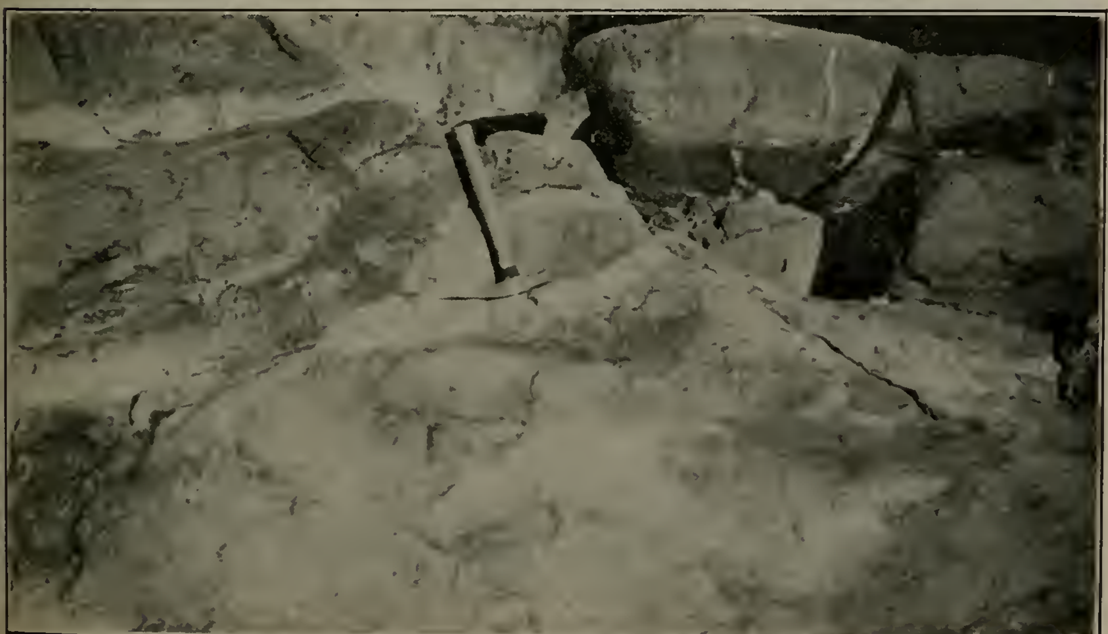
GENERAL TOPOGRAPHIC AND GEOLOGIC FEATURES
PERTAINING TO
DAMSITES ON NORTH AND SOUTH FORKS
OF AMERICAN RIVER

Note: Investigation limited to areas marked for legend.

PLATE XIV



Typical amphibolite schist. Jointed massive amphibolite.
Upper Auburn dam site on North Fork American River.



Massive amphibolite—Schistose development (at hammer). Quartz vein fillings.
Lower Auburn dam site on North Fork American River.

erosive development of the streams they have met the massive bands to turn and follow the southwesterly strike of the less resistant schistose bands for short distances before cutting southeasterly across the trend of the massive bands. The side streams are developed along the schist bands. There, slopes are gentle and soil covering is the heaviest. Thus the topographic development has resulted in draws marking the schistose bands and ridges marking the more resistant massive bands. Where the massive bands have been crossed by the rivers the hard resistant rock stands at steep angles above streambed, outcrops of rock make up a large portion of the slope, and soil covering is shallow. Geologically and topographically the most desirable dam sites will be located at points where the streams cross the spurs of massive amphibolite.

Upper Auburn site.

At the junction of the Middle Fork with the North Fork of the American River lies a body of slate containing siliceous layers resembling chert and a limestone deposit which has been extensively quarried. The black slates merge with the green amphibolite downstream. The Upper Auburn dam site is located in the amphibolite less than 1000 feet distant from the contact. Over this distance the rocks have developed a marked schistosity and the prevailing rock bands are hornblende schist which has, in some places, altered to chlorite schist, a green flaky mass on the canyon sides which has weathered to a reddish clay soil.

The proposed Upper Auburn site contains a topographic draw which has developed along a band of chlorite schist. Bordering the chlorite schist band are bands of hornblende schist, downstream and upstream, which merge into massive bands of relatively limited thickness. The hornblende schist does not weather as readily as does the chlorite schist, but it and the massive phase at the dam site have developed two main systems of joints which have weakened the outcrop exposures. These joints' systems are at right angles and oblique angles with the schistosity and large blocks of rock have been displaced along these lines of weakness.

That these materials are firmer and much more indurated below ground surface than might be expected from the weathered exposures on the canyon sides, is attested to by the character of rock exposed by stream erosion in the bottom of the canyon. It is my opinion that the site could be made to serve as a foundation for the structure proposed were no better site available. The disadvantages would be in the amount of stripping necessary to reach firm indurated rock in place.

Lower Auburn site.

In passing downstream from the Upper Auburn site the same material, in bands, occurs with the green chlorite schist bands becoming less pronounced. The stream cuts across the bands at right angles to their strike for about a mile and a quarter below the junction. At three-quarters of a mile a band of fully developed chlorite schist is exposed which merges into hornblende schist. From this point to

PLATE XV

Left abutment. Weathering of schist. | Right abutment. Jointing of schist. | Stream bed. Indurated schist.

Upper Auburn dam site on North Fork American River.

Right abutment. | Left abutment. | Right abutment.

Massive amphibolite at Lower Auburn dam site on North Fork American River.

beyond the Lower Auburn site the schistosity is not so marked nor is there parting along joints, and the rock has resisted erosion.

The massive phase of the amphibolite predominates and at the dam site occurs a massive band some five hundred feet in thickness in which the rock resembles the original diabase, portions of which have developed schistosity. The whole has been so thoroughly indurated by the deposition of secondary quartz that it has been the controlling feature of the topographic development. The canyon sides are precipitous, rock outcrops continuously and soil covering is shallow. Joint

PLATE XVI

Upper portion of right abutment.
Lower Auburn dam site on North Fork American River.

blocks have been carried away as they developed on the steep canyon sides so that stripping will probably be limited to that necessary to key in the structure.

Just below this spur occurs a more schistose band and the stream turns to the southwest along its strike and side canyons have been developed. Above the spur the stream bed drops less than twenty feet to the mile, while in the four-mile stretch below it drops 120 feet. The topographic development suggests waterfall conditions during the erosive history of the North Fork of the American River at this point, and it is probable that pot holes of some extent will be found in the rock bottom of the stream. In my opinion the geological and topographical conditions at this point combine to make an excellent site and foundation for the major structure proposed.

Pilot Creek dam site.

The most conspicuous topographic feature of the region examined is the high ridge which strikes northwest-southeast across the region, the highest point of which is Pilot Hill. This spur is crossed by the North Fork of the American River at Pilot Creek. From the dam of the North Fork Ditch Company downstream to Pilot Creek the topographic development in the bands of more fully developed schistosity and jointing have produced gentler slopes and numerous draws. Few massive bands exist and these have not sufficient width extent to become important until the Pilot Hill spur is reached.

Pilot Creek has eroded the southerly wall of the American River Canyon where it crosses the massive amphibolite. But just below the junction of Pilot Creek with the river exists an excellent site for the structure proposed. The canyon walls rise at steep angles from a narrow stream bed. Stripping should be at a minimum and firm rock should be found at shallow depth below stream bed.

PLATE XVII

Right. Left.

Massive amphibolite spur.
Pilot Creek dam site on North Fork American River.

Upper Coloma dam site.

An area of granitic rock lies intrusive in the metamorphics along the South Fork of the American River from Coloma downstream to Hastings Creek. Such intrusions are the most effective agents of contact metamorphism and, as is of common occurrence, there is found a zone of highly metamorphosed rock along Hastings Creek and in the vicinity of its junction with the South Fork of the American River where the upper Coloma dam site is located. The metamorphic rocks of this zone are composed of a number of lesser zones or bands of rock in which the alteration decreases in passing downstream from the intrusion. Physical changes, due to baking, as well as complete chemical changes, are apparent in very limited distances.

Such changes have produced an area over which the rocks are not homogeneous in the mass, part readily from each other, and react to weathering and other conditions with considerable variance one from another. These bands strike across the dam site, dipping about 45 degrees upstream. The most conspicuous band is composed of serpentine. In the river bed exposure it is brittle flaky green rock but under exposure to the atmosphere on the canyon walls it has broken down to an incoherent mass of clayey soil. In that condition it has

PLATE XVIII

Serpentine outcrop (right bank). Broken rock and soil (left bank).
Upper Coloma Dam site on South Fork American River

slid out of place down the canyon sides, which accounts for the landslide topography. The serpentine found at the dam site is a thoroughly altered derivative. It is subject to further decomposition by simply softening to dirt and clay, usually accompanied by swelling. Shear and crushed zones border the serpentine. It is difficult to anticipate how deep the decomposition and shearing has taken place or how rapidly will the serpentine decompose upon exposure and stripping. It is very poor foundation rock and as it dips under the dam site makes the site unsuited for the major structure proposed.

PLATE XIX

Shattered rock and decomposed serpentine slide (left bank).
Upper Coloma dam site on South Fork American River.

Higher portion of landslide topography. Face of landslide the top of which appears in picture at left.

Upper Coloma dam site on South Fork American River.

Lower Coloma dam site.

For the reasons stated above, it was considered expedient to examine the South Fork channel below Hastings Creek in considerable detail for the purpose of obtaining a substitute site which would be suitable. Downstream from the highly metamorphosed zone above described was found slates, chert, and siliceous beds resembling quartzite. Some diabase also was found. About two-thirds of a mile downstream chlorite schist crosses the stream bed. The stream to this point follows the strike of the cleavage of the slate. A resistant band of amphibolite turns the stream about one mile below the upper Coloma site but the topographic development prohibits its use as a dam site.

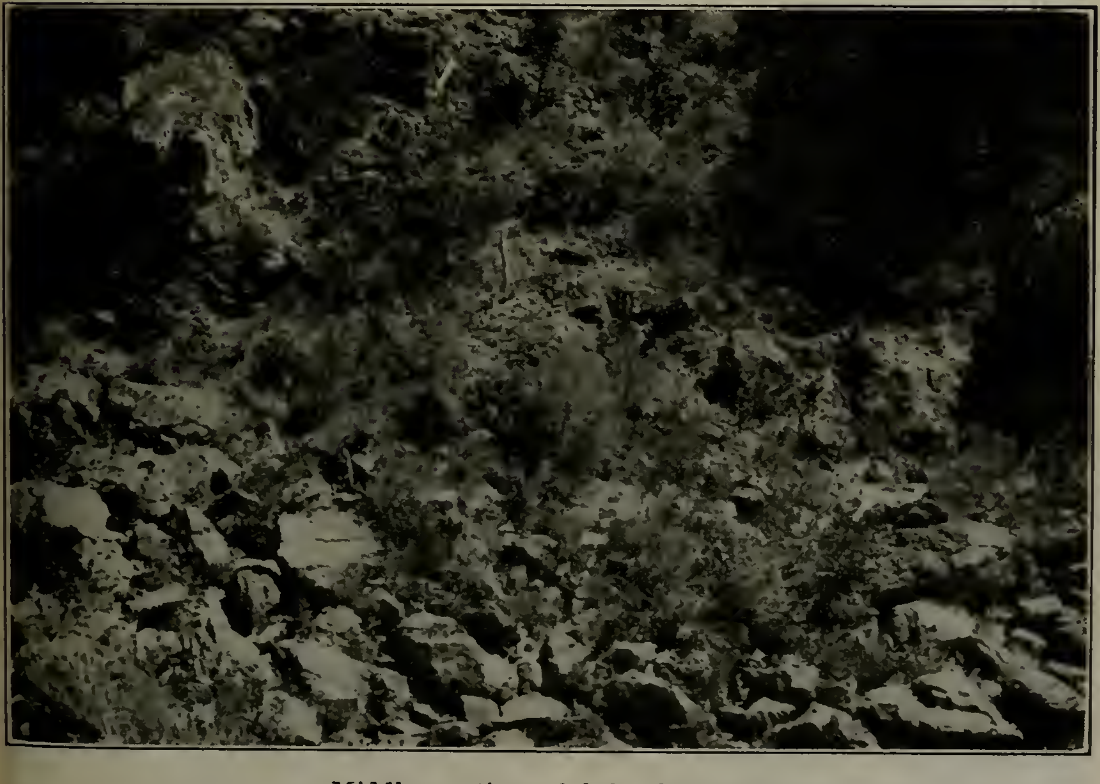
Amphibolite, resembling closely that found along the North Fork of the river, continues with no suitable dam sites for a distance of three and one-quarter miles below the upper Coloma dam site. At that point the Pilot Hill spur is cut by the South Fork, diagonally across the strike of the band. The formation is the massive phase, described in connection with the Pilot Creek dam site on the North Fork. It has here resisted erosion so that the stream channel is narrow and the canyon walls rise abruptly from a stream bed elevation of about 550 feet to over 900 feet above sea level. In my opinion the topographic and geologic conditions here obtaining provide an excellent dam site.

PLATE XX

Massive amphibolite outcrops and joint blocks.
Lower Coloma dam site on South Fork American River.

PLATE XXI

Upper portion of left abutment.
Lower Coloma dam site on South Fork American River.



Middle portion of left abutment.
Lower Coloma dam site on South Fork American River.

Webber Creek dam site.

The proposed development of the South Fork of the American River calls for a low height (100–150 feet) dam to utilize the head between the Coloma dam site and the Folsom reservoir. It was desired to obtain a site for this dam as low as possible on the river. For that reason the river channel was examined from Salmon Falls upstream.

Just above the Salmon Falls bridge the South Fork of the American River has cut its course through an area of intrusive igneous rock which continues, with varying phases of texture and mineral constituents, upstream as far as the investigation went.

The igneous mass is a dark green rock of granitoid texture whose main mineral constituents are pyroxene, hornblende, and plagioclase. Quartz is present as a secondary mineral in the lighter phases. The mass contains areas which are composed almost entirely of hornblende, which may be primary. These areas make up the more resistant portions and mark the narrow gorge, precipitous walled portions of the river course. Beginning at about stream bed elevation 430 and continuing upstream for several hundred feet the river cuts westerly across such an area. The stream bed is narrow and the side walls rise abruptly above it the full height of the proposed structure. The rock is hard and durable, difficult to break under blows of a hammer. Detailed surveys will reveal the best topographic location for the dam site, within an extensive area whose rock will afford an excellent foundation for a dam, require a minimum of stripping and should present shallow depth of stream bed materials. The site takes its name from Webber Creek which enters the South Fork about 1½ miles above the proposed location.

PLATE XXII

Hornblende rock—Secondary quartz filling.
Webber Creek dam site on South Fork American River.
Looking downstream.

PLATE XXIII

Webber Creek dam site on South Fork American River.
Looking upstream.

Folsom dam site.

The Folsom dam site is located upon the American River below the junction of the South Fork with the North Fork and a short distance above the point where the river leaves an extensive area whose country rock has been designated granodiorite by the United States Geological Survey. This term is a contraction of granite-diorite employed to distinguish the intermediate rock between granite and quartz diorite. The latter strongly resembles granite, physically and chemically, and for the purpose of this report the rock will be referred to by its local name in general use—granite. The dam site lies wholly within the granite area with topographic differences due largely to the effect of erosion and attack of the weather upon rock of fairly uniform characteristics. There are no evidences of major lines of structural weakness in the vicinity.

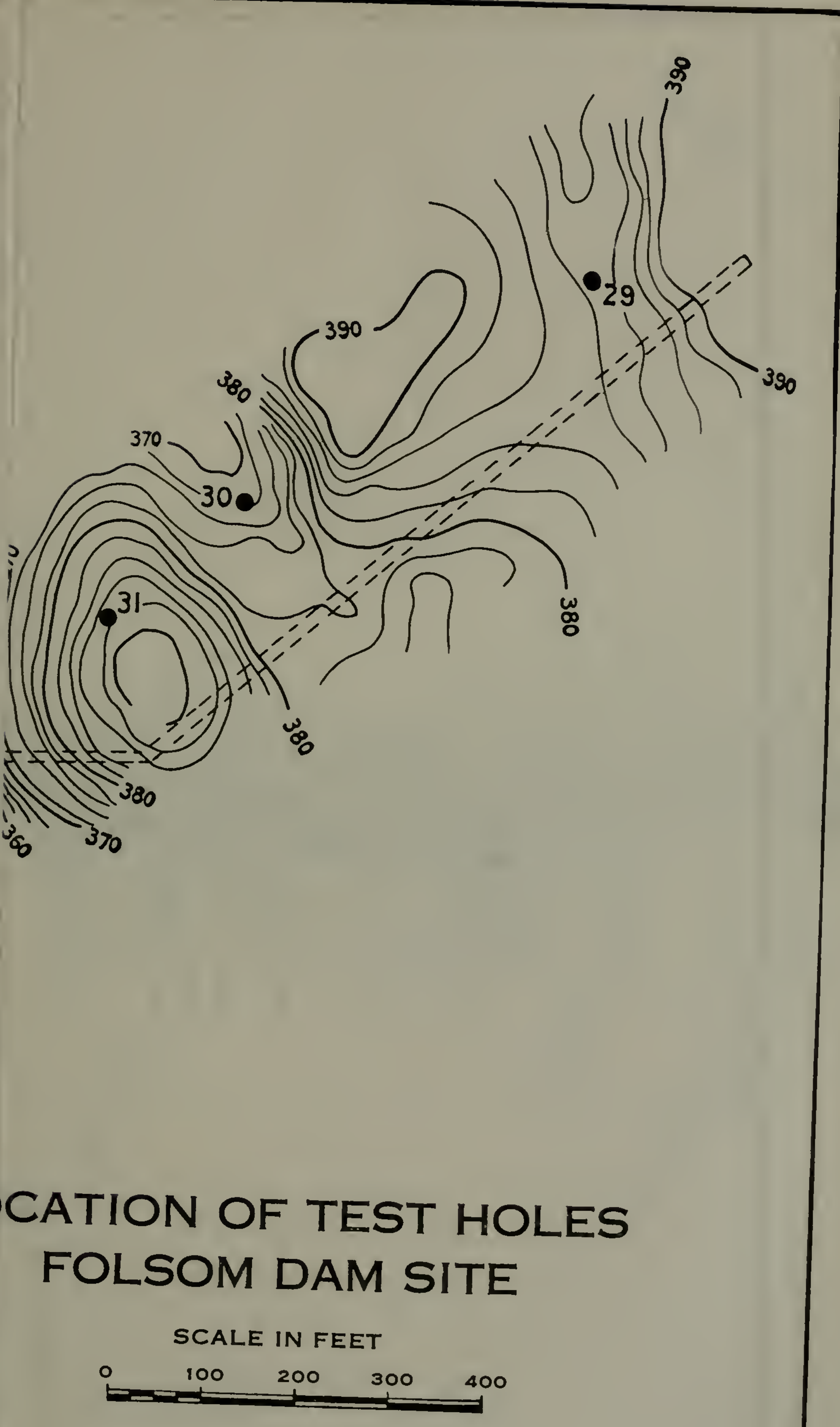
Contrary to the popular conception, granite is one of the least durable of the crystalline rocks. The constitutent mineral crystals of the granite at the dam site are mainly hornblende, the mica biotite, quartz, and feldspar. As the original molten mass cooled, these relatively large crystals formed, interlocking with each other, until the whole became converted into a mass of interlocking crystals, firmly knit together into a strong crystalline rock mass. However, this crystal fabric is subject to breakdown and the tenacity or bond of the fabric is overcome by the forces of weathering. Temperature changes cause the rock surface to break down through the unequal contraction and expansion of the component crystals. Minute cracks open as the crystals part from each other and surface moisture, penetrating through these openings, enlarges them and further weakens the rock through the removal or alteration of some of its mineral constituents. This process of disintegration may continue to some considerable depth below the ground surface, the residuum or so-called rotten granite, remaining in place over the unweathered portions. Such material is a physically weak crumbly mass, subject to penetration and percolation of water, and readily eroded.

The surface of the dam site is spotted with outcrops of unweathered granite but the larger portion of the dam site surface is made up of the rock in varying stages of disintegration, ranging from the completely broken down and altered product—clay soil—to rock which may be broken down with a hand pick. The driller's logs of the test holes bored across the dam site show disintegration to be uneven as to depth, increasing generally from upstream to downstream, with a maximum depth to solid rock of forty-three feet on the west and thirty-eight feet on the east abutment. All of this residuum must be removed in stripping the dam site and the structure keyed in to the firm unaltered granite to depths of at least five feet.

The residuum is rapidly carried away through erosion on the slopes and bottom of the gorge at the dam site and the unweathered granite exposed below elevation 325 on the east and 340 on the west abutments is firm. The rock mass has developed three major systems of joints; one striking southwesterly, diagonally across the dam site but parallel to the stream course just above the site, and dipping 75 degrees from the horizontal; one striking southeasterly making about an 80-degree angle with the first and dipping 75 degrees from the horizontal, and an intersecting horizontal joint dipping N. 75° about 25 degrees. At the surface these joints are opened and in many places a weathered zone (rotten granite) ranging from one to eight inches in width borders the joints.

The presence of secondary quartz filling in the joints in the freshly eroded granite at stream level and considerable quartz float in the soil indicate that the older and larger seams and joints, below the weathered zone, are probably closed to the passage of water. However, the diamond drill core records show "seamy" and rotten granite zones and an examination of the cores reveals joints, which persist to depths in excess of fifty feet, through which water has circulated and whose wall material has disintegrated. It will therefore be necessary to carry out a systematic program of pressure grouting over the dam site, the location, number, depth and direction of the grout holes being dependent upon the joints revealed when the site is stripped.

The design of the dam calls for two flood spillways, four hundred feet in length, along the crest of each abutment as part of the structure. This portion of the structure will lie along the flatter portions of the dam site where disintegration has progressed to the greatest depths. It will be necessary to strip and treat the foundation over these stretches as carefully and fully as the stretch upon which the gravity dam section will be founded. The wasteway to the river from the spillway crest may require a "cascade" treatment of the natural rock slopes. The waste discharge may equal one hundred thousand cubic feet of water per second and further consideration must be given to the ability of the rock to withstand the effects of such floods and the weather.



)CATION OF TEST HOLES
FOLSOM DAM SITE

SCALE IN FEET

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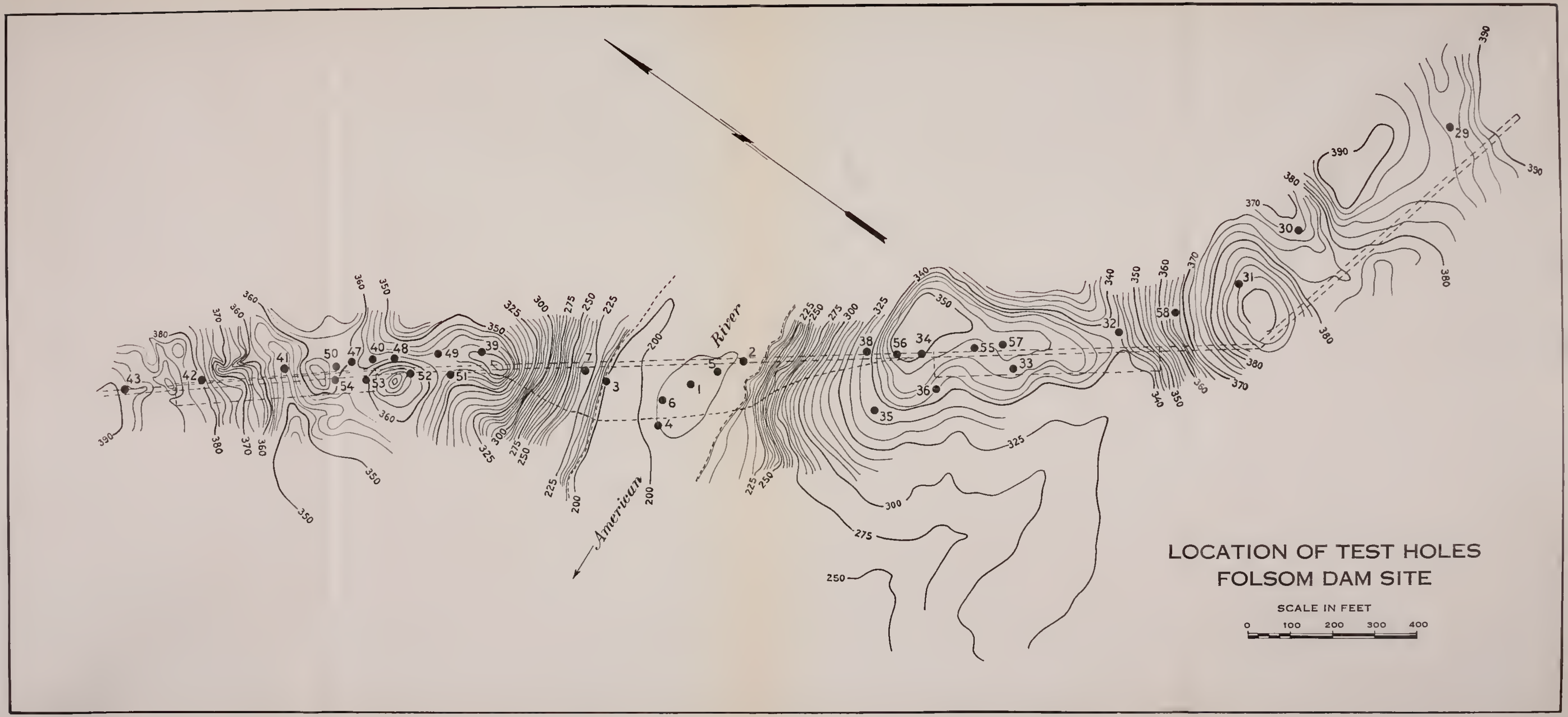
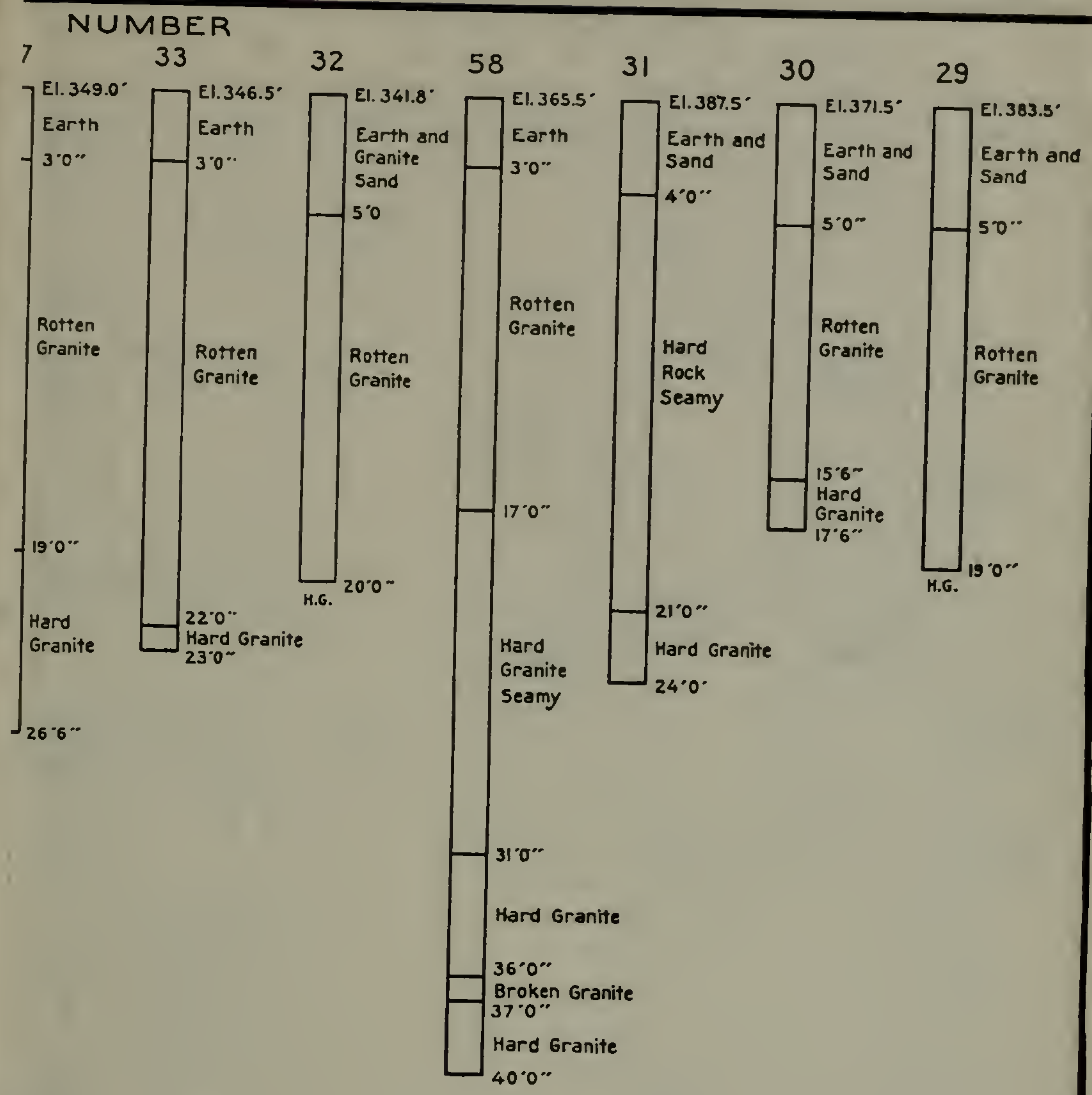
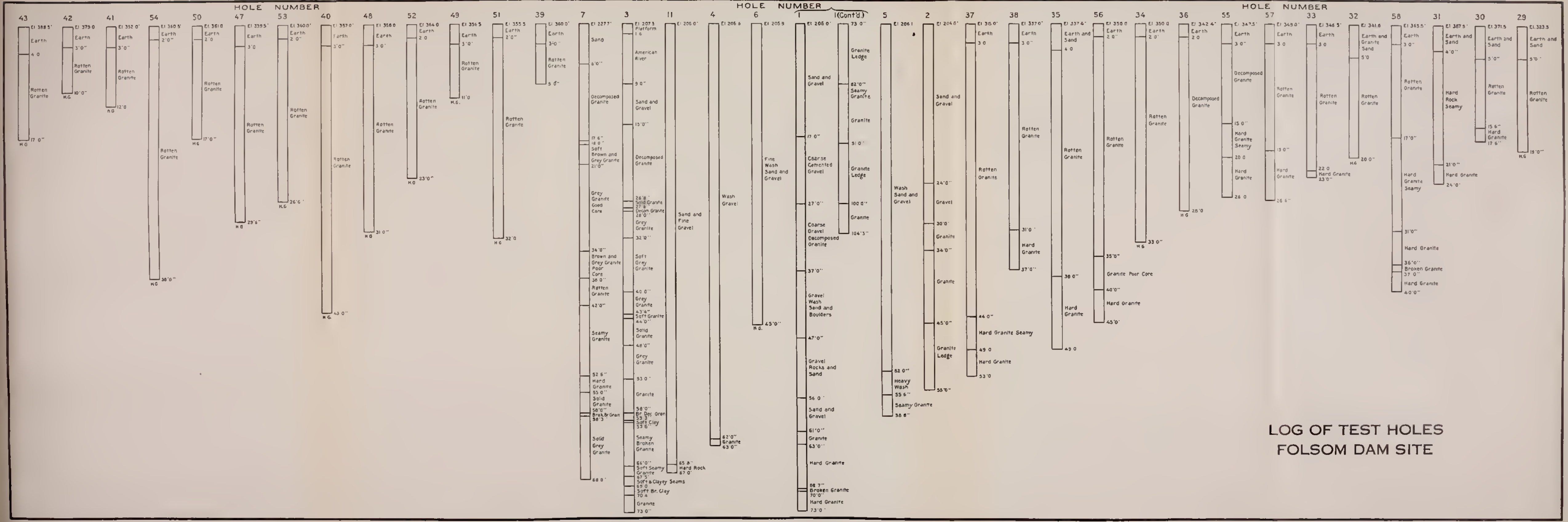


LOCATION OF TEST HOLES
FOLSOM DAM SITE

SCALE IN FEET



LOG OF TEST HOLES
FOLSOM DAM SITE



LOG OF TEST HOLES
FOLSOM DAM SITE

PUBLICATIONS

DIVISION OF WATER RESOURCES

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PUBLICATIONS OF THE

DIVISION OF WATER RESOURCES

DEPARTMENT OF PUBLIC WORKS

STATE OF CALIFORNIA

When the Department of Public Works was created in July, 1921, the State Water Commission was succeeded by the Division of Water Rights, and the Department of Engineering was succeeded by the Division of Engineering and Irrigation in all duties except those pertaining to State Architect. Both the Division of Water Rights and the Division of Engineering and Irrigation functioned until August, 1929, when they were consolidated to form the Division of Water Resources.

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*Bulletin No. 2—Kings River Investigation, Water Master's Reports, 1918–1923.
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*Bulletin No. 2—Irrigation Districts in California, 1887–1915.
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*Bulletin No. 4—Preliminary Report on Conservation and Control of Flood Waters in Coachella Valley, California, 1917.
*Bulletin No. 5—Report on the Utilization of Mojave River for Irrigation in Victor Valley, California, 1918.
*Bulletin No. 6—California Irrigation District Laws, 1919 (now obsolete).
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* Reports and Bulletins out of print. These may be borrowed by your local library from the California State Library at Sacramento, California.

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*Bulletin No. 1—California Irrigation District Laws, 1921 (now obsolete).
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* Reports and Bulletins out of print. These may be borrowed by your local library from the California State Library at Sacramento, California.

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